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CHLORDANE AND HEPTACHLOR IN RELATION TO MAN AND THE ENVIRONMENT

A FURTHER PESTICIDE REVIEW 1972-1975

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IN RELATION TO MAN AND THE ENVIRONMENT -
A FURTHER REVIEW, 1972 - 1975

Criteria and Evaluation Division
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U.S. Environmental Protection Agency
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PREFACE

Because of the Environmental Protection Agency's statutory mandate to protect the public health and well being of its citizenry through control of economic poisons, a comprehensive effort intended to insure intensive and regular review of all economic poisons was initiated March 18, 1971, to identify those pesticides which could represent potential unreasonable adverse effects on man and his environment. Since that date comprehensive "internal reviews" have been conducted on a number of pesticides by the staff of the Office of Pesticide Programs.

Chlordane and heptachlor were initially reviewed in 1971 - 1972 by the Office of Pesticide Programs. The reviews, available from the Environmental Protection Agency, are entitled: Pesticidal Aspects of Chlordane in Relation to Man and the Environment, 1972 and Heptachlor - A Review of Its Uses, Chemistry, Environmental Hazards, and Toxicology, 1972.

This report presents an additional review of both chlordane and heptachlor, which is intended to present selected papers appearing in the literature from 1972-1975. The review indicates new and significant literature in the areas of fish, wildlife, distribution in the environment (air, soil, water), residues in crops and food items, and toxicology and epidemiology. The chemistry information for 1972-1975 was published as a part of a 1975 amendment to the 1972 reviews.

This review summarizes rather than interprets scientific data studies in the process of updating the earlier reviews of chlordane and heptachlor. It is not intended to correlate data from different sources or present opinions on contradictory findings.

The review covers all uses of the pesticides in the United States and should be applicable to future needs in the Agency. The review was researched and prepared by the Criteria and Evaluation Division, Office of Pesticide Programs, EPA.

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SUMMARY

Chlordane and heptachlor were initially reviewed by the Office of Pesticide Programs, Environmental Protection Agency. The present review primarily presents selected significant papers which have appeared in the literature from 1972-1975. The amounts of chlordane and heptachlor used in the United States have continued to increase since 1972. It is estimated that the use-distribution of chlordane in the United States during 1974 was as follows: 68% for termite control; 10% for home and garden uses; and, 22% for agricultural uses. The use-distribution of heptachlor in the United States during 1974 has been estimated as follows: 50% for agricultural uses, primarily on corn; 34% for termite control; and, 16% for home and garden pests.

The recent development of a high purity technical chlordane (less than 1% heptachlor content) presents a new pesticide product which is being evaluated for efficacy and hazard in the environment.

Studies of chlordane in the soil have demonstrated that alpha and gamma chlordane are the major components of the pesticide found in soil. Heptachlor has been reported to be a minor component of this soil residue. Chlordane has been confirmed to be relatively immobile in soil.

Data show that chlordane will translocate to certain crops, primarily the root crops. It has been suggested that the atmosphere is a transport route for chlordane from site of soil application to the oceans. Studies suggest organochlorine pesticides reside in the atmosphere either as vapors or are included on dust particles. The pesticides are then "scrubbed out" by rain and snow.

Studies have indicated that normal agricultural pesticide applications did not appear to endanger most farmstead water supplies.

Heptachlor is rapidly metabolized in flooded soil whereas its metabolite, heptachlor epoxide, was not detected in the flooded soil. Previous studies have shown that heptachlor epoxide would be formed from heptachlor in aerobic non-flooded soil. Chlordane remains stable under both these conditions for three months. Residues of chlordane and heptachlor have been found in sediments at levels much higher than the associated water residues.

Low levels of chlordane and heptachlor have been shown to be toxic to aquatic life. The effects have been studied with oysters and several species of fish. Recent studies have established levels of maximum acceptable toxicant concentration (MATC) for chlordane and heptachlor through use of chronic exposure tests with several species of aquatic animals. Chlordane, heptachlor and heptachlor epoxide residues are widespread.

Residues of heptachlor epoxide are relatively widespread in wildife, but at generally low levels. In recent years, dramatic wildlife kills have not been attributed to the major uses of chlordane and heptachlor in the United States. A recommendation was made that the heptachlor use as a seed dressing for cereal grains be suspended as of January 1, 1974 in Canada.

Early market basket surveys conducted by the Food and Drug Administration demonstrate that chlordane is only infrequently found in total diet studies. However, the Food and Drug Administration did report finding chlordane in processed foods examined in fiscal year 1973 at a 5% relative frequency. The USDA did find chlordane in 17.7% of fat tissues analyzed from livestock in 1974.

Market basket surveys for FY 1973 and 1974 indicate heptachlor epoxide occurs commonly in dairy products and meat, fish and poultry.

Carcinogenic studies for chlordane and heptachlor are currently underway at the National Cancer Institute, the National Institute of Health and the U.S. Department of Health, Education and Welfare. A preliminary report is available at this time.

Oxychlordane, a metabolite of chlordane is stored in rat adipose tissue. Trans-chlordane resulted in greater oxychlordane storage than cis-chlordane in both sexes of rats with lower accompanying parent isomer storage.

Studies of human tissues from various areas of the world indicate widespread distribution of heptachlor epoxide. Certain studies indicate the ability of heptachlor epoxide to cross the placental barrier.

CHAPTER I

Current Chlordane and Heptachlor Uses With Their Impact On the Environment and Alternatives

This review of chlordane and heptachlor uses is intended to update the information presented in the Reviews of 1972.

Of the total United States consumption of heptachlor in 1974, it is estimated that the use-distribution was as follows: 50% agriculture, primarily corn; 34% termite control; and 16% home and garden and miscellaneous uses.

The United States use-distribution of chlordane in 1974 has been estimated as follows: 22% agriculture; 68% termite control; and 10% home and garden and miscellaneous uses.

Of the heptachlor uses currently registered, only those for snap beans, cabbage, lettuce and rutabagas have established tolerances of 0.1 ppm. The remainder of the registered heptachlor uses have had registrations extended to allow gathering of data to support proposed tolerances (Code of Federal Regulations, Section 180.104).

Interim tolerances have been set for blackberries, blueberries, boysenberries, dewberries, raspberries at 0.01 ppm, tomatoes at 0.02 ppm and peppers at 0.1 ppm (Code of Federal Regulations, Section 180.319).

In 1960, zero heptachlor tolerances were established for barley, corn, oats, pineapples, wheat and rye. Registration for these latter uses has been extended until sufficient data to support a finite tolerance are submitted.

The majority of crops for which chlordane has a registered use have a tolerance of 0.3 ppm (Code of Federal Regulations, Section 180.122). This tolerance has been reaffirmed for most crops in a Federal Register notice of September 21, 1973. The registrations have been extended to allow time to gather data supporting proposed tolerances.

Interim tolerances for extended registrations are as follows: Asparagas, mustard greens, pumpkins and spinach at 0.1 ppm, parsnips, at 0.2 ppm and bananas at 0.03 ppm (Code of Federal Regulations, Section 180.319).

Seed treatment applications of chlordane utilize 2 oz of actual chlordane per bushel of seed. Recent reports indicate this treatment is effective in preventing seed-feeding damage by seed-corn beetles, seed-corn maggots, and wireworms, except where resistance of the three pests is either confirmed or suspected.

This chapter presents the currently registered uses of chlordane and heptachlor, according to current use patterns, along with an update of the known registered alternative pesticides (see I.A. and I.B.).

I.A. Summary of Registered Chlordane Uses and Alternatives

Animals

Brown Dog Tick - Naled, Carbaryl.

Demodectic Mange Mites - Lindane.

Fleas - Allethrins, Lindane, Benzobenzoate, Methoxychlor, Naled, Coumaphos, Dioxthion, Baygon, Carbaryl, Malathion, Diazinon, Trichlorofon, Ronnel, Chlorpyrifos, Cythioate, Pyrethrins, Rotenone, Rabon, DDVP, Compound 4072, Resmethrin.

Flies - Lindane, Methoxychlor, Ciodrin, Pyrethrins, DDVP.

Lice - Lindane, Benzobenzoate, Coumaphos, Methoxychlor, Dioxthion, Carbaryl, Malathion, Ronnel, Pyrethrins, Rotenone, DDVP, Lethane 384, Ciodrin, Toxaphene.

Mites - Ronnel, Pyrethrins.

Psoroptic Mange Mites - Lindane.

Ticks - Allethrins, Lindane, Methoxychlor, Naled, Coumaphos, Dioxthion, Baygon, Carbaryl, Malathion, Diazinon, Dylox, Ronnel, Pyrethrins, Rabon, DDVP, Compound 4072, Ciodrin, Toxaphene.

Field Crops

Corn

Ants - Carbaryl.

Armyworm - Methoxychlor, Methyl parathion, Carbaryl, Malathion, Diazinon, Toxaphene.

Climbing Cutworms - Methyl parathion, Toxaphene.

Corn Rootworms - Methyl parathion, Phorate, Malathion, Diazinon, Disulfaton, Bux, Dasanit, Furadan, Dyfonate, Mocap.

Crickets - Carbaryl, Trichlorofon, Toxaphene.

Cutworms - Methyl parathion, Carbaryl, Diazinon, Trichlorofon, Toxaphene, Dylox.

Earwigs - Carbaryl.

Flea Beetles - Methoxychlor, Methyl parathion, Carbaryl, Malathion, Diazinon, OMPA, Toxaphene.

Corn (continued)

Grasshoppers - Mevinphos, Methoxychlor, Methyl parathion, Carbaryl, Malathion, Diazinon, Endosulfan, Toxaphene.

Japanese Beetle - Methoxychlor, Carbaryl, Malathion, OMPA, Toxaphene.

June Beetles - Carbaryl.

Mole Crickets - Diazinon.

Root Maggots - Diazinon.

Rose Chafer - Methoxychlor.

Slugs - Metaldehyde.

Snails - Metaldehyde.

Sowbugs - Carbaryl.

Wireworms - Lindane, D-D Mixture, Diazinon, EDB, Dasanit, Dyfonate, Furadan, Mocap.

Cotton

Ants - Carbaryl.

Aphids - Phosphamidon, Perthane, Disulfaton, Naled, Dimethoate, Bidrin, EPN, Methyl parathion, Carbaryl, Phorate, Demeton, Malathion, Diazinon, Guthion, Ethion, Metasystox-R, Endosulfan, Toxaphene, Monitor, Endrin.

Beet Armyworm - EPN, Methyl parathion, Trichlorofon, Guthion, Azodrin, Toxaphene, Monitor.

Boll Weevil - Naled, Bidrin, EPN, Methyl parathion, Carbaryl, Malathion, Guthion, Endosulfan, Toxaphene, Endrin.

Bollworm - Naled, EPN, Methyl parathion, Carbaryl, Malathion, Guthion, Chlordioneform, Chlordioneform Hydrochloride, Endosulfan, Toxaphene, Methyl bromide, Endrin.

Cabbage Looper - Bacillus Thuringiensis, Naled, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Guthion, Endosulfan, Toxaphene, Monitor.

Cotton Fleahopper - Naled, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Trichlorofon, Guthion, Carbophenothion, Endosulfan, Toxaphene.

Cotton (continued)

Cotton Leafworm - Naled, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Diazinon, Trichlorofon, Guthion, Carbophenothion, Ethion, Endosulfan, Toxaphene.

Crickets - Carbaryl, Trichlorofon, Toxaphene.

Cutworms - Endrin, Methyl parathion, Carbaryl, Malathion, Trichlorofon, Guthion, Toxaphene.

Darkling Beetles - Carbaryl.

Fall Armyworm - Naled, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Guthion, Toxaphene.

Flea Beetles - Phosphamidon, Naled, Methyl parathion, Carbaryl, Endosulfan, Toxaphene.

Fleahoppers - Phosphamidon, Perthane, Naled, Dimethoate, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Trichlorofon, Guthion, Endosulfan, Toxaphene.

Garden Webworm - Perthane, Endrin, EPN, Methyl parathion, Malathion, Diazinon, Guthion, Toxaphene.

Grasshoppers - Naled, Dimethoate, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Guthion, Toxaphene.

Lygus Bugs - Phosphamidon, Naled, Dimethoate, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Diazinon, Dylox, Guthion, Ethion, Azodrin, Endosulfan, Toxaphene.

Stink Bugs - Endrin, Methyl parathion, Carbaryl, Malathion, Diazinon, Trichlorofon, Guthion, Endosulfan, Toxaphene.

Tarnished Plant Bug - Endrin EPN, Methyl parathion, Carbaryl, Guthion, Toxaphene.

Thrips - Phosphamidon, Disulfaton, Naled, Dimethoate, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Phorate, Demeton, Malathion, Guthion, Azodrin, Endosulfan, Toxaphene, Monitor.

Wireworms - Lindane D-D Mixture, EDB.

Soybeans

Crickets - Dylox, Toxaphene.

Grasshoppers - Naled, Methyl parathion, Carbaryl, Malathion, OMPA, Toxaphene.

Soybeans (continued)

Stink bugs - Naled, EPN, Methyl parathion, Carbaryl, Malathion, Dylox, Guthion, OMPA, Endosulfan, Toxaphene.

Wireworms - Lindane, D-D Mixture, Diazinon.

Tobacco

Ants - Carbaryl.

Cutworms - Lindane, Methyl parathion, Carbaryl, Malathion, Diazinon, Trichlorofon, Endosulfan, Toxaphene.

Grasshoppers - Naled, Methyl parathion, Carbaryl, Malathion, Diazinon, Guthion, Endosulfan.

Green June Beetle - Methyl parathion, Trichlorofon.

Hornworms - Naled, Methyl parathion, Carbaryl, Malathion, Trichlorofon, Guthion, Endosulfan.

Mole Crickets - Diazinon.

White Grubs - Methyl Bromide, Chloropicrin.

Wireworms - Chloropicrin, Lindane, D-D Mixture, Diazinon, Dyfonate, EDB, Methyl bromide, Mocap.

Field Crops Other Than Corn, Cotton, Soybeans and Tobacco

Alfalfa Weevil - Mevinphos, Methoxychlor, Dimethoate, Methyl parathion, Carbaryl, Malathion, Guthion, Imidan, Toxaphene.

Ants - Carbaryl.

Armyworm - Methyl parathion, Carbaryl, Malathion, Toxaphene.

Corn Rootworms - Phorate, Diazinon.

Crickets - Carbaryl, Trichlorofon.

Cutworms - Trichlorofon, Carbaryl, Diazinon, Toxaphene, Endrin.

Darkling Beetles - Carbaryl.

Flea Beetles - Methoxychlor, Carbaryl.

Other field crops (continued)

Grasshoppers - Mevinphos, Methoxychlor, Naled, Dimethoate, Methyl parathion, Carbaryl, Malathion, Diazinon, OMPA, Toxaphene, Cabofuran, Endosulfan.

Lygus Bugs - Mevinphos, Methoxychlor, Naled, Dimethoate, Methyl parathion, Carbaryl, Malathion, Diazinon, Trichlorofon, Guthion, Metasystox-R, Toxaphene, Methomyl, Carbofuran.

Mole Crickets - Trichlorofon.

Rice Leaf Miner - Methyl parathion, Malathion.

Wireworms - D-D Mixture, EDB, Lindane, Diazinon, Dyfonate, Phorate.

Fruits (Excluding Small Fruits)

Ants - Carbaryl, Malathion.

Aphids - Lindane, Mevinphos, Perthane, Methoxychlor, Dimethoate, Methyl parathion Nicotine sulfate, Carbaryl, Demeton, Malathion, Diazinon, Guthion, Carbophenothion, Metasystox-R, Endosulfan, TEPP, Phoslon, Ethion.

Bagworm - Methoxychlor, Carbaryl, Malathion, OMPA.

Catfacing Insects - Endosulfan, Methyl parathion, Malathion, Lindane, Carbaryl, Diazinon.

Codling Moth - Phosphamidon, Methoxychlor, Perthane, Dioxithion, EPN, Methyl parathion, Morestan, Carbaryl, Malathion, Diazinon, Guthion, Carbophenothion, Ethion, OMPA, Imidan, Gardona, Chlordimeform, Chlordimeform hydrochloride, Endosulfan, Methomyl, Phosalone.

Cutworms - Carbaryl.

Flea Beetles - Lindane, Methoxychlor, Malathion, Diazinon.

Grasshoppers - Lindane, Mevinphos, Perthane, Dimethoate, Carbaryl, Malathion, Toxaphene, Naled.

Green June Beetle - Carbaryl.

Oriental Fruit Moth - Methoxychlor, Methyl parathion, Carbaryl, Malathion, Toxaphene.

Fruits (Excluding Small Fruits) (continued)

Plum Curculio - Lindane, Perthane, Methoxychlor, EPN, Methyl parathion, Morestan, Carbaryl, Malathion, Diazinon, Guthion, OMPA, Imidan, Gardona, Phosalone, Toxaphene, Endosulfan.

Rose Chafer - Methoxychlor, Carbaryl, Malathion.

Spider Mites - Kelthane, Mevinphos, Kelthane, Malathion, Carbophenothion, Diazinon.

Thrips - Lindane, Methoxychlor, Dimethoate, Malathion, Diazinon, TEPP, Toxaphene, Guthion, Naled, Carbaryl.

White Grubs - Chloropicrin.

Wireworms - D-D Mixture, EDB, Chloropicrin.

Ornamentals

Ants - Metasystox, Metasystox-R, Tetradifon, Toxaphene, Allethrin, Chloropyrifos, Fenthion, Diazinon, Lindane, Di-Syston, Carbaryl, Carbophenothion, Disulfoton, Malathion, Ovex, Methoxychlor, Naled.

Aphids - Phorates, Ovex, DDVP, Metasystox, Rotenone, Endosulfan, Acephate, Perthane, Methyl parathion, Nicotine, Dichlone, Lindane, Disulfoton, Methoxychlor, Carbaryl, Malathion, Trichlorofon, Metasystox-R, Toxaphene, Naled, Dimethoate, Mexacarbate, Demeton, Diazinon, OMPA, Resmethrin, Allethrin.

Armyworm - Mexacarbate, Methoxychlor, Carbaryl, Malathion, Chloropyrifos, Toxaphene, Metasystox-R.

Bagworm - Methychlor, Carbaryl, Malathion, Diazinon, Trichlorofon, OMPA, Metasystox-R, Toxaphene, Acephate, Lindane, Chloropyrifos, Carbophenothion, Ovex, Bacillus, Thuringiensis.

Billbugs - Diazinon.

Birch Leafminer - Diazinon, Disulfoton, Malathion, Carbaryl, Demeton.

Blister Beetles - Methoxychlor, Lindane, OMPA, Malathion, Carbaryl, Metasystox-R.

Boxelder Bug - Methoxychlor, Carbaryl, Malathion, Chloropyrifos.

Ornamentals (continued)

Brown Dog Tick - Chloropyrifos.

Cabbage Looper - Methyl parathion.

Carnation Bud Mite - Diazinon.

Carnation Shoot Mite - Diazinon.

Centipedes - Carbaryl, Malathion.

Chinch Bug - Ethion, Chloropyrifos, Aspon.

Climbing Cutworms - Allethrin, Dichlone, Methoxychlor, Carbaryl, Malathion, Trichlorofon, Metasystox-R, Lindane, Toxaphene.

Clover Mite - Karathane, Mexacarbate, Lindane, Kelthane.

Crickets - Diazinon, Chloropyrifos, Carbaryl, Malathion, Trichlorofon.

Cutworms - Mexacarbate, Diazinon, Chloropyrifos, Malathion, Endrin, Lindane, Carbaryl, Toxaphene, Perthane, Methoxychlor, Metasystox-R, Naled, Trichlorofon, Metasystox.

Cyclamen Mite - Kelthane, Diazinon.

Digger Wasps - Diazinon.

Dipterous Leafminers - Trichlorofon, Metasystox-R.

Earwigs - Diazinon, Chloropyrifos, Malathion, Carbaryl, Lindane, Naled, Carbophenothion, Toxaphene, Sodium fluosilicate, Tetradifon, Metasystox, Metasystox-R.

Elm Leaf Beetle - Carbaryl, OMPA, Naled, Toxaphene, Methoxychlor, Malathion, Metasystox-R.

European Chafer - Chloropyrifos, Diazinon.

European Pine Shoot Moth - Mexacarbate, Lindane, Carbaryl, Phorate, Malathion.

European Red Mite - Kelthane, Dioxathion, Demeton, Diazinon.

Fall Armyworm - Carbaryl, Tetradifon, Toxaphene.

Fall Webworm - Bacillus Thuringiensis.

Ornamentals (continued)

Fiery Skipper - Lindane, Ethlene dichloride, Toxaphene.

Flea Beetles - Lindane, Methoxychlor, Carbaryl, Malathion, Toxaphene, Diazinon, OMPA, Dichlone, Rotenone, Trichlorofon.

Fleas - Malathion, Carbophenothion, Ethion, Lindane, Carbaryl, Diazinon, Chloropyrifos, Toxaphene, Naled, Tetradifon, Disulfoton, EDC, Ronnel, DDVP.

Flies - Methoxychlor, Malathion, Diazinon.

Gnats - Methoxychlor, Malathion.

Grasshoppers - Methoxychlor, Malathion, Chloropyrifos, Toxaphene, Lindane, Diazinon, Carbophenothion, Ethion, Carbaryl.

Holly Bud Moth - Diazinon.

Holly Leafminer - Diazinon.

Japanese Beetle - Carbaryl, Malathion, Methoxychlor, OMPA, Chloropyrifos, Resmethrin, Allethrin, Lindane, Metasystox-R, Metasystox, Ovex, Diazinon, Rotenone.

June Beetles - Carbaryl.

Lace Bugs - Demeton, Phorate, Metasystox-R, Carbaryl, Malathion, Diazinon, Resmethrin, OMPA, Lindane, Methoxychlor, Toxaphene, Disulfoton, Dimethoate, Acephate, Allethrin, Ovex, Dichlone, Nicotine sulfate, Rotenone.

Leaf Beetles - Carbaryl.

Leafhoppers - Phorate, Dichlone, Ovex, Nicotine sulfate, Lindane, Disulfoton, Methoxychlor, Chloropyrifos, Carbaryl, Malathion, Trichlorofon, Metasystox-R, Toxaphene, Mexacarbate, Naled, Demeton, Diazinon, OMPA, Resmethrin, Allethrin, Bacillus Thuringiensis, Rotenone, Carbophenothion, Tetradifon, DDVP, Metasystox, Dimethoate.

Leafminers - Metasystox-R, Carbaryl, Metasystox, Mexacarbate, Lindane, Methoxychlor, Naled, Dimethoate, Diazinon, Acephate, Malathion.

Leafrollers - Carbaryl, OMPA, Lindane, Ovex, Malathion, Naled.

Ornamentals (continued)

Loopers - Mexacarbate, Naled.

Lygus Bugs - Trichlorofon, Metasystox-R, Malathion, Methoxychlor, Diazinon, Acephate, Allethrin, Resmethrin, Ovex, Methoxychlor, Perthane.

Millipedes - Lindane, Mexacarbate, Carbaryl, Diazinon, Toxaphene, EDC, Malathion, Carbophenothion, Tetradifon.

Mites - Chloropyrifos, DDVP, Rynadin, Karathane, Dinsulfoton, Diazinon, Trichlorofon, Metasystox-R.

Mole Crickets - Lindane, Diazinon, Carbophenothion, Ethion, Chloropyrifos, Toxaphene.

Mosquitoes - Carbaryl, Lindane, Methoxychlor, Malathion, Diazinon, Chloropyrifos, Tetradifon, Allethrin, DDVP.

Oak Kermes - Lindane, Carbaryl, Phorate, Malathion.

Plant Bugs - Lindane, Disulfoton, Methoxychlor, Carbaryl, Malathion, Toxaphene, OMPA, Resmethrin, Allethrin, Dichlone, Metasystox-R.

Privet Mite - Toxaphene, Kelthane.

Psyllids - Carbaryl, Lindane, Metasystox-R.

Rhododendron Borer - Lindane.

Rose Chafer - Carbaryl, Lindane, Methoxychlor, Malathion, Disulfoton, Endosulfan, Perthane.

Scales - Carbaryl, Dimethoate.

Scorpions - Diazinon.

Scurfy Scale - Lindane, Carbaryl, Phorate, Malathion.

Slugs - Mexacarbate, Metaldehyde, Carbaryl, Mesurol.

Snails - Mexacarbate, Metaldehyde, Carbaryl, Mesurol.

Sod webworms - Diazinon, Carbaryl, Tetradifon, Chloropyrifos.

Sowbugs - Mexacarbate, Carbaryl, Diazinon, Chloropyrifos, Lindane, Naled, Malathion, Metasystox-R, Carbophenothion, Ethion, Toxaphene.

Ornamentals (continued)

Spider Mites - Disulfoton, Malathion, Nicotine sulfate, Phorate, Kelthane, Naled, Karathane, Demeton, DDVP.

Spiders - Malathion, Diazinon.

Spittlebugs - Resmethrin, Endrin, Chloropyriphos, Lindane, Allethrin, Toxaphene.

Stink Bugs - Dylox, Lindane, Carbaryl.

Tarnished Plant Bugs - Malathion, Chloropyrifos, Carbaryl, Methoxychlor Dylox, Metasystox-R.

Tent Caterpillars - Methoxychlor, Carbaryl, Malathion, Lindane, Mexacarbate, Diazinon, Ovex, Naled, Toxaphene, Metasystox-R.

Thrips - Dimethoate, Dichlone, Endrin, Nicotine sulfate, Lindane, Disulfoton, Methoxychlor, Rotenone, Carbaryl, Malathion, Trichlorofon, Phorate, Metasystox-R, Toxaphene, Naled, Mexacarbate, Demeton, Diazinon, Metasystox, OMPA, Resmethrin, Allethrin, DDVP.

Ticks - Diazinon, Carbaryl, Lindane, Methoxychlor, Naled, Dioxathon, Malathion, Carbophenothion, Ethion, Metasystox-R, Chloropyrifos, Toxaphene, DDVP.

Webworms - Trichlorofon, Metasystox-R, Metasystox, Carbaryl, Diazinon, Methoxychlor.

Whiteflies - Mexacarbate, Methoxychlor, Malathion, Chloropyrifos, Disulfoton, Dylox, Metasystox-R, Allethrin, Lindane, Perthane, Naled, Carbaryl, Demeton, Diazinon, Metasystox, DDVP, Resmethrin.

White Grubs - Diazinon, Lindane, Toxaphene, Methyl bromide, Chloropicrin, Methoxychlor, Naled, EDC, Trichlorofon, Carbophenothion, Ethion, Metasystox-R.

Willow Leaf Beetles - Carbaryl, Malathion, Methoxychlor.

Wireworms - Chloropicrin, Lindane, Methoxychlor, Naled, Diazinon, Metasystox-R, Methyl bromide, D-D Mixture.

Premises (Indoor)

Ants - Lindane, Methoxychlor, Lethane, Malathion, Ronnel, DDVP, Pyrethrins, Baygon, Diazinon.

Premises (Indoor) (continued)

Bees - Pyrethrins.

Brown Dog Tick - Naled, DDVP, Baygon, Carbaryl, Malathion, Diazinon, Chloropyrifos, DDVP.

Cadelle - Methoxychlor, Ethylenedichloride, Pyrethrins, EDB, Methyl bromide.

Cockroaches - Diazinon, Ronnel, DDVP, Baygon, Lindane, Fenthion, Malathion, Trichlorofon, Pyrethrins, Chloropyrifos.

Crickets - Baygon, Ronnel, Pyrethrins.

Fleas - Thanite, Diazinon, Chloropyrifos, Ronnel, Rotenone, DDVP, Compound 4072, Pyrethrins, Naled, Dioxathion, Carbaryl, Resmethrin, Lindane, Lethane, Methoxychlor, Baygon, Malathion.

Flies - Lindane, Malathion, Trichlorofon, Ronnel, DDVP, Pyrethrins, Lethane 384, Methoxychlor, Carbaryl, Diazinon, Fenthion, Resmethrin.

Gnats - Pyrethrins, DDVP, Methoxychlor, Malathion, Resmethrin.

Granary Weevil - Lindane, Methoxychlor, Malathion, Pyrethrins, Ethylene dichloride, Methyl bromide.

Hornets - Pyrethrins, DDVP, Resmethrin.

Mosquitoes - Lindane, Malathion, Ronnel, DDVP, Pyrethrins, Lethane 384, Methoxychlor, Carbaryl, Fenthion, Diazinon, Resmethrin.

Rice Weevil - Lindane, Methoxychlor, Malathion, Pyrethrins, EDB, Ethylene dichloride, Methyl bromide, Trichlorethylene.

Silverfish - Ronnel, DDVP, Pyrethrins, Baygon, Lindane, Methoxychlor, Malathion, Diazinon.

Spiders - Lethane 384, Methoxychlor, Malathion, Ronnel, DDVP, Baygon, Pyrethrins.

Ticks - Naled, Dioxithon, Carbaryl, Baygon, Malathion, Compound 4072, Lindane, Methoxychlor, Pyrethrins, DDVP.

Wasps - Ronnel, Pyrethrins, DDVP, Fenthion, Resmethrin.

Premises (Outdoor)

Ants - Carbaryl, Malathion, Diazinon, Ronnel, Pyrethrins, DDVP, Resmethrin, Lindane, Lethane 384, Methoxychlor, Toxaphene.

Premises (Outdoor) (continued)

Brown Dog Tick - DDVP.

Cockroaches - Malathion, Diazinon, Toxaphene, DDVP, Dylox, Pyrethrins.

Fleas - Lindane, Lethane 384, Methoxychlor, Malathion, Ronnel, Pyrethrins, Toxaphene, DDVP.

Flies - Lindane, Lethane 384, Methoxychlor, Naled, Baygon, Malathion, Ronnel, Pyrethrins, Toxaphene, DDVP, Resmethrin, Thanite, Trichlorofon.

Gnats - Lindane, Malathion, Pyrethrins, Toxaphene, DDVP, Lethane 384, Naled, Thanite, Ciodrin.

Grasshoppers - Carbaryl, Diazinon, Toxaphene.

Mosquitoes - Lindane, Lethane 384, Methoxychlor, Malathion, Ronnel, Pyrethrins, Toxaphene, DDVP, Resmethrin, Naled, Thanite, Ciodrin.

Powderpost Beetles - Pentachlorophenol.

Silverfish - Ronnel, Pyrethrins, DDVP.

Spiders - Lethane 384, Methoxychlor, Malathion, Ronnel, Pyrethrins, DDVP.

Termites (Wood) - Chromic Acid, Copper Naphthanate, Pentachlorophenol, Zinc Naphthanate, Copper sulfate, Pentahydrate, Creosote.

Wood Boring Insects - Copper Naphthanate, Creosote, Pentachlorophenol.

Seed Treatment

Wireworms - Lindane, Diazinon.

Small Fruits

Ants - Carbaryl, Methyl bromide, Chloropicrin.

Cabbage Looper - Mevinphos, Carbaryl, Malathion.

Climbing Cutworms - Toxaphene.

Crickets - Lindane, Methoxychlor, Carbaryl, Malathion, Toxaphene.

Cutworms - Carbaryl, Malathion, Lindane, Toxaphene.

Darkling Beetles - Carbaryl.

Small Fruits (continued)

Earwigs - Carbaryl, Lindane.

False Chinch Bug - Methyl parathion.

Field Crickets - Methoxychlor, Carbaryl, Malathion, Endosulfan.

Flea Beetles - Methoxychlor, Carbaryl, Malathion, Diazinon.

Fuller Rose Beetle - Guthion.

Grasshoppers - Lindane, Mevinphos, Naled, Endrin, Carbaryl, Toxaphene.

Japanese Beetle - Methoxychlor, Carbaryl, Malathion.

Leaf Miners - Diazinon.

Lygus Bugs - Endosulfan, Mevinphos, Methoxychlor, Carbaryl, Malathion.

Mole Crickets - Diazinon.

Pill Bugs - Lindane, Methoxychlor, Naled, Carbaryl, Malathion, Diazinon, Endosulfan.

Rose Chafer - Methoxychlor, Carbaryl.

Slugs - Metaldehyde, Carbaryl.

Snails - Metaldehyde.

Stink Bugs - Mevinphos, Carbaryl, Guthion.

Strawberry Crown Borer - Toxaphene.

Strawberry Root Weevil - Malathion, Methoxychlor, Endosulfan.

Strawberry Weevil - Lindane, Perthane, Methoxychlor, Naled, Carbaryl, Malathion, Toxaphene.

Thrips - Endosulfan, Naled, Methyl parathion, Carbaryl, Malathion, Guthion, Mevinphos, Methoxychlor, Diazinon.

White Grubs - Chloropicrin, Lindane, Methyl bromide.

Wireworms - D-D Mixture, Chloropicrin, EDB, Methyl bromide.

Small Grains

Armyworms - Endrin, Methyl parathion, Malathion, Toxaphene.

Small Grains (continued)

Crickets - Trichlorofon.

Grasshoppers - Methyl parathion, Carbaryl, Malathion, Toxaphene, Phorate.

Wireworms - Lindane, D-D Mixture.

Vegetables

Ants - Allethrin, Carbaryl, Malathion, Pyrethrum, Methyl bromide, Chloropicrin.

Armyworm - Carbaryl, Malathion, Endosulfan, Toxaphene, Mevinphos, Methoxychlor, Methyl parathion, Naled, Diazinon, Ethion, Monuron, Lindane.

Asparagus Beetle - Lindane, Methoxychlor, Carbaryl, Malathion, Ethion, OMPA, Rotenone, Mevinphos, Methyl parathion, Diazinon, Pyrethrum, Dylox, Endosulfan, Toxaphene.

Bean Leaf Beetle - Methoxychlor, Carbaryl, Ethion, Rotenone, Endosulfan, Toxaphene.

Bean Leafroller - Toxaphene.

Beet Armyworm - Malathion, Rotenone.

Blister Beetles - Methoxychlor, Carbaryl, Rotenone, Methyl parathion, Malathion, Naled, Endosulfan, Toxaphene, Diazinon, Rotenone.

Cabbage Looper - Bacillus Thruingiensis, Methyl parathion, Carbaryl, Malathion, Rotenone, Mevinphos, Endrin, Methoxychlor, Naled, Methylene chloride, Carbophenothion, Endosulfan, Toxaphene, Methomyl, Monitor.

Cabbage Maggot - Lindane, Guthion.

Carrot Rust Fly - Rotenone.

Centipedes - Diazinon.

Climbing Cutworms - EPN, Toxaphene, Mevinphos, Endrin, Naled, Methyl parathion, Carbaryl, Endosulfan, Malathion, Pyrethrum, Lindane, Dylox, Methoxychlor.

Colorado Potato Beetle - Perthane, Phorate, Imidan, Methoxychlor, Carbaryl, Malathion, Rotenone, Naled, Carbofuran, Mevinphos, Ethion, OMPA, Guthion, Monitor, Pyrethrum, Toxaphene, Endosulfan, Methyl parathion, Diazinon, Phosphamidon, Disulfoton.

Vegetables (continued)

Corn Earworm - Mevinphos, Naled, Carbaryl, Malathion, Carbophenothion.

Crickets - Carbaryl, Toxaphene, Malathion, Trichlorofon, Lindane, Naled, Endosulfan.

Cross-striped Cabbageworm - Mevinphos, Methyl parathion, Malathion, Endosulfan, Pyrethrum.

Cucumber Beetles - Methoxychlor, Methyl parathion, Carbaryl, Malathion, Diazinon, Ethion, OMPA, Rotenone, Endosulfan, Toxaphene, Pyrethrum, Lindane, Phosphamidon, Naled, DDVP, Monuron, Mevinphos.

Cutworms - Carbaryl, Malathion, Diazinon, Toxaphene, Lindane, Mevinphos, Endosulfan, Dylox, Naled, Methyl parathion, Gardona.

Darkling Beetle - Carbaryl.

Earwigs - Carbaryl, Malathion, Lindane.

Fall Armyworm - Methoxychlor, Carbaryl, Malathion, Naled, Methyl parathion, Diazinon, Endosulfan.

Flea Beetles - Carbophenothion, DDVP, Mevinphos, Methoxychlor, Methyl parathion, Carbaryl, Malathion, Guthion, Ethion, OMPA, Rotenone, Toxaphene, Endosulfan, Diazinon, Naled, Lindane, Disulfoton, Phorate, Pyrethrum, Phosphamidon, Metasystox-R, Monitor, EPN.

Garden Webworm - Malathion.

Grasshoppers - Lindane, Carbaryl, Mevinphos, Dimethoate, Endrin, Malathion, Diazinon, Toxaphene, Naled, Endosulfan, Perthane, Guthion.

Green Stink Bug - Sabadilla, Malathion, Endosulfan, Mevinphos, Naled, Carbaryl, Pyrethrum, Ethion, Diazinon, Guthion.

Harlequin Bug - DDVP, Endosulfan, Toxaphene, Diazinon, Pyrethrum, Sabadilla, Carbaryl, OMPA, Malathion, Mevinphos, Naled, Monuron, Methyl parathion, Rotenone.

Hornworms - Mevinphos, Phosphamidon, Methoxychlor, Naled, Methyl parathion, Carbaryl, Malathion, Guthion, Endosulfan, Toxaphene, Gardona.

Imported Cabbage Worm - Malathion, Carbophenothion, Pyrethrum, Rotenone, Carbaryl, OMPA, Endosulfan, Bacillus Thuringiensis, Phosphamidon, Toxaphene, Methoxychlor, Naled, Methomyl, Methyl parathion, Ronnel, Diazinon, Dylox, Monitor, Guthion.

Vegetables (continued)

Japanese Beetle - Methoxychlor, Carbaryl, Malathion, OMPA, Rotenone, Endosulfan, Toxaphene.

June Beetle - Carbaryl.

Leafhoppers - Mevinphos, Disulfoton, DDVP, Methoxychlor, Naled, Dimethoate, Endrin, EDC, Methyl parathion, Carbaryl, Phorate, Malathion, Diazinon, Guthion, Carbophenothion, Ethion, OMPA, Pyrethrum, Rotenone, Ryanodine, Endosulfan, Toxaphene, Phosphamidon, Sabadilla, Nicotine sulfate, Bacillus Thruingiensis, Demeton, Metasystox-R, Perthane.

Leafminers - Naled, Dimethoate, Methyl parathion, Malathion, Diazinon, Guthion, Ethion, Endosulfan, Lindane, Phosphamidon, Ethylene Dichloride, Guthion, Disulfoton, Carbaryl, Phorate, Toxaphene.

Leafrollers - Malathion, Naled, Methyl parathion.

Lygus Bugs - Sabadilla, Mevinphos, Naled, Dimethoate, Methyl parathion, Carbaryl, Phorate, Malathion Carbophenothion, Ethion, Rotenone, Ryanodine, Toxaphene, Endosulfan, Methoxychlor, Trichlorofon, Ronnel, Lindane.

Melonworm - Lindane, Methyl parathion, Carbaryl, Malathion, Ethion, OMPA, Pyrethrum, Rotenone, Endosulfan, DDVP.

Mexican Bean Beetle - Sabadilla, Mevinphos, Methoxychlor, Naled, Monuron, Endrin, EPN, Methyl parathion, Carbaryl, Phorate, Malathion, Diazinon, Guthion, Ethion, OMPA, Rotenone, Endosulfan, Toxaphene.

Mole Crickets - Diazinon, Dylox.

Onion Maggot - Diazinon, Lindane, Dasanit, Malathion, Carbophenothion, Rotenone.

Onion Thrips - Naled, Methyl parathion, Carbaryl, Phorate, Malathion, Diazinon.

Pea Weevil - Methoxychlor, Malathion, Rotenone, Toxaphene, Methyl parathion, Carbaryl, Pyrethrum, Endosulfan.

Pepper Weevil - Methoxychlor, Toxaphene.

Plant Bugs - Mevinphos, Carbaryl, Methyl parathion, Endosulfan, Lindane, Toxaphene, Malathion.

Vegetables (continued)

Potato Flea Beetle - Methoxychlor, Methyl parathion, Carbaryl, Malathion, Diazinon, Imidan, Endosulfan, Carbofuran, Monitor.

Potato Leafhopper - Methoxychlor, Methyl parathion, Carbaryl, Malathion, Diazinon, Imidan, Endosulfan, Carbofuran, Monitor.

Potato Psyllid - Disulfoton, Methoxychlor, Methyl parathion, Phorate, Malathion, Endosulfan, Carbophenothion.

Root Aphids - Disulfoton, Phorate.

Root Maggots - Diazinon.

Rose Chafer - Methoxychlor, Carbaryl, Malathion, Rotenone, Pyrethrum.

Serpentine Leafminer - EPN, Carbaryl, Toxaphene, Carbophenothion, Diazinon, Ethion, Dylox, Endosulfan, Methyl parathion.

Slugs - Carbaryl, Metaldehyde.

Snails - Carbaryl, Metaldehyde.

Sowbugs - Carbaryl.

Spotted Cucumber Beetle - Lindane, Methoxychlor, Carbaryl, Malathion, Guthion, Pyrethrum, Rotenone.

Squash Bug - Sabadilla, Lindane, Methoxychlor, Methyl parathion, Carbaryl, Malathion, Ethion, OMPA, Pyrethrum, Endosulfan, Rotenone, Dylox.

Squash Vine Borer - Methoxychlor, Malathion, Diazinon, Ethion, Pyrethrum, Rotenone, Endosulfan, Carbaryl, Lindane.

Stink Bug - Mevinphos, Naled, Monuron, Methyl parathion, Carbaryl, Malathion, Guthion, OMPA, Rotenone, Endosulfan, Bacillus Thuringiensis, Ryanodine, Methoxychlor, Lindane, Phosphamidon.

Striped Cucumber Beetle - Rotenone, Pyrethrum, Sabadilla, Lindane, Methoxychlor, Carbaryl, Malathion, Guthion.

Thrips - Lindane, Mevinphos, Disulfoton, Methoxychlor, Naled, Dimethoate, EPN, Methyl parathion, Carbaryl, Phorate, Malathion, Diazinon, Carbophenothion, Ethion, Rotenone, Ryanodine, Endosulfan, Toxaphene, Pyrethrum, Trichlorofon, Ronnel, DDVP, Nicotine sulfate, Guthion.

Vegetables (continued)

Tomato Hornworm - Carbaryl, Rotenone, Methoxychlor, Naled, Malathion, Ethion, Endosulfan, Bacillus Thuringiensis, Toxaphene, EPN, Methyl parathion.

White Grubs - Lindane, Chloropicrin, Methyl bromide.

Wireworms - EDB, D-D Mixture, Diazinon, Lindane, Chloropicrin, Phorate, Dyfonate, Methyl bromide.

I.B. Summary of Registered Heptachlor Uses and Alternatives

Field Crops

Corn

Ants - Carbaryl.

Billbug - Toxaphene.

Cutworms - Carbaryl, Dylox, Diazinon, Methyl parathion, Trichlorofon, Toxaphene.

Rootworms - Bux, Dasanit, Furadan, Diazinon, Dyfonate, Mocap, Methyl parathion, Phorate, Malathion, Disulfoton.

Wireworms - Dyfonate, Dasanit, Diazinon, Furadan, Mocap, Lindane, D-D Mixture, EDB.

Cotton

Boll weevil - Naled, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Endosulfan, Toxaphene, Guthion.

Cotton Fleahopper - Naled, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Trichlorofon, Guthion, Carbophenothion, Endosulfan, Toxaphene.

Cutworms - Endrin, Guthion, Malathion, Methyl parathion, Carbaryl, Trichlorofon, Toxaphene.

Fleahopper - Phosphamidon, Perthane, Dimethoate, Naled, Bidrin, Endrin, EPN, Methyl parathion, Carbaryl, Malathion, Trichlorofon, Guthion, Carbophenothion, Endosulfan, Toxaphene.

Tarnished Plant Bug - Endrin, EPN, Methyl parathion, Carbaryl, Guthion, Toxaphene.

Thrips - Azodrin, Phosphamidon, Endosulfan, Disulfoton, Naled, Toxaphene, Dimethoate, Bidrin, Monitor, Endrin, EPN, Methyl parathion, Carbaryl, Phorate, Demeton, Malathion, Guthion.

Soybeans

Wireworms - Lindane, D-D Mixture, Diazinon.

Tobacco

Cutworms - Lindane, Malathion, Endosulfan, Carbaryl, Methyl parathion, Diazinon, Trichlorofon, Toxaphene.

Field Crops (continued)

Tobacco (continued)

White Grubs - Methyl bromide, Chloropicrin.

Wireworms - Lindane, Dyfonate, EDB, Methyl bromide, Diazinon, Chloropicrin, D-D Mixture, Mocap.

Ornamentals

Ants - Carbaryl, Metasystox, Lindane, Diazinon, Malathion, Resmethrin, Metoxychlor, Chloropyrifos, Naled, Di-Syston, Metasystox-R, Toxaphene, Allethrin, Fenthion, Tetradifon, Carbophenothion, Disulfoton, Ovex.

Aphids - Methoxychlor, Carbaryl, Malathion, Resmethrin, DDVP, Allethrin, Lindane, Diazinon, Trichlorofon, Metasystox-R, Toxaphene, Mexacarbate, Disulfoton, Phorate, Ovex, Metasystox, Rotenone, Endosulfan, Acephate, Perthane, Methyl parathion, Nicotine, Dichlone, Naled, Dimethoate, Demeton, OMPA.

Armyworms - Malathion, Toxaphene, Mexacarbate, Methoxychlor, Carbaryl, Chloropyrifos, Metasystox-R.

Asiatic Garden Beetle

Black Vine Weevil

Crickets - Trichlorofon, Chloropyrifos, Diazinon, Carbaryl, Malathion.

Cutworms - Lindane, Mexacarbate, Carbaryl, Diazinon, Chlorpyrifos, Toxaphene, Methoxychlor, Naled, Trichlorofon, Malathion, Endrin, Perthane, Metasystox-R.

Earwigs - Carbaryl, Diazinon, Lindane, Naled, Malathion, Toxaphene, Chloropyrifos, Carbophenothion, Sodium Fluosilicate, Tetradifon, Metasystox, Metasystox-R.

Fleas - Chloropyrifos, Lindane, Ronnel, Naled, Toxaphene, DDVP, Diazinon, Carbaryl, Malathion, Carbophenothion, Ethion, Tetradifon, Disulfoton, EDC.

Grasshoppers - Chlorpyrifos, Carbaryl, Methoxychlor, Malathion, Toxaphene, Lindane, Diazinon, Carbophenothion, Ethion.

Japanese Beetle - Methoxychlor, Carbaryl, Malathion, Chlorpyrifos, Resmethrin, Allethrin, Lindane, Toxaphene, OMPA, Metasystox-R, Metasystox, Ovex, Diazinon, Rotenone.

Field Crops (Continued)

Ornamentals

June Beetles - Carbaryl.

Mole Crickets - Lindane, Diazinon, Chlorpyrifos, Toxaphene, Carbophenothion, Ethion.

Slugs - Mexacarbate, Metaldehyde, Carbaryl, Mesurol.

Snails - Mexacarbate, Carbaryl, Metaldehyde, Mesurol.

Sod webworms - Carbaryl, Diazinon, Chlorpyrifos, Tetradifon.

Sowbugs - Mexacarbate, Carbaryl, Diazinon, Chlorpyrifos, Malathion, Lindane, Naled, Metasystox-R, Carbophenothion, Ethion, Toxaphene.

Spider mites - Kelthane, Malathion, Nicotine sulphate, Disulfoton, Phorate, Naled, Karathane, Demeton, DDVP.

Ticks - Lindane, Methoxychlor, Naled, Dioxathion, Carbaryl, Malathion, Diazinon, Chlorpyrifos, Toxaphene, DDVP, Carbophenothion, Ethion, Metasystox-R.

White grubs - Lindane, Diazinon, Toxaphene, Chloropicrin, Methoxychlor, Naled, Methyl bromide, EDC, Trichlorofon, Carbophenothion, Ethion, Metasystox-R.

Wireworms - Lindane, Chloropicrin, Methoxychlor, Naled, Diazinon, Methyl bromide, D-D Mixture, Metasystox-R.

Mosquitoes - Pyrethrins, Carbaryl, Diazinon, Lindane, Methoxychlor, Malathion, Chlorpyrifos, Tetradifon, Allethrin, DDVP.

Narcissus Bulb Fly - Ronnel, Trichlorofon.

Premises (Domestic Dwellings - Indoors)

Ants - Pyrethrins, Lindane, Methoxychlor, Lethane, Malathion, Ronnel, DDVP, Baygon, Diazinon.

Cockroaches - Pyrethrins, Diazinon, Ronnel, DDVP, Baygon, Lindane, Fenthion, Malathion, Trichlorofon, Chlorpyrifos.

Flies - DDVP, Lindane, Malathion, Trichlorofon, Ronnel, Pyrethrins, Lethane 384, Methoxychlor, Carbaryl, Diazinon, Fenthion, Resmethrin.

Silverfish - Pyrethrins, Ronnel, DDVP, Baygon, Lindane, Methoxychlor Malathion, Diazinon.

Field Crops (continued)

Premises (Domestic Dwellings - Indoors) (continued)

Silverfish - Pyrethrins, Ronnel, DDVP, Baygon, Lindane, Methoxychlor Malathion, Diazinon.

Seed Treatment

Wireworms - Lindane, Diazinon.

Small Fruits

Strawberry Root Weevil - Malathion, Methoxychlor, Endosulfan.

Small Grains

Cutworms - Endrin, Methyl parathion, Toxaphene.

Vegetables

Cabbage Maggot - Lindane, Guthion.

Cutworms - Lindane, Carbaryl, Mevinphos, Methyl parathion, Diazinon, Toxaphene, Gardona, Malathion, Endosulfan, Dylox, Naled.

Root Maggots - Diazinon.

White Grubs - Lindane, Chloropicrin, Methyl bromide.

Wireworms - Lindane, D-D Mixture, EDB, Diazinon, Chloropicrin, Phorate, Dyfonate, Methyl bromide.

I.C. Discussion of Chlordane and Heptachlor Usage Patterns and Alternative Chemicals - in 1972, the EPA Special Pesticide Review Group studied the toxicological hazard to man and the environment associated with the use of chlordane as a pesticide in the United States. In making this study, the Group consulted pesticide experts in EPA and other Federal agencies and evaluated the information received in response to the Federal Register notice on chlordane and heptachlor (36 FR 6606). In this study, the Group used a questionnaire, prepared by the Office of Pesticide Programs of EPA and sent by the U.S. Department of Agriculture to state extension directors and directors of state agricultural experiment stations, to enable both agencies to better assess the impact of cancellation of chlordane and heptachlor on American agriculture.

The questionnaire related to projected state recommendations for these insecticides in 1975. Although these are recommendations only and may not be followed by all users, their advocacy does represent the thinking of state entomologists as to the most efficacious treatments. We must presume that the majority of users ahere to these recommendations. Some measure of usage patterns of chlordane and heptachlor may thus be derived from state recommendations.

Table 1 was derived from this USDA/EPA questionnaire and lists those states responding to our inquiry, the state estimates of total pounds actual of chlordane and heptachlor used in 1974, and whether they will or will not recommend these insecticides in 1975 for other than structural use against termites or the dipping of nursery stock.

I.C.1. Discussion of Chlordane and Heptachlor Uses Being Recommended - Table 1 presents a brief summary of the recommendation plans of the various states for chlordane and heptachlor. This section is intended to highlight comments which are very significant to a review of the two pesticides.

I.C.1.a. Soil Applications - This is by far the most extensive agricultural use of chlordane and heptachlor. The comments indicated that the principal soil application recommendations for 1975 will be corn, strawberries, and potatoes. Many states advocate soil treatment of ornamentals including flowers and trees.

I.C.1.b. Foliar Applications - The only foliar applications of chlordane which will be recommended in 1975 are insect pests on strawberries in Missouri and cotton pests in Arkansas. It is possible that other foliar recommendations were not clearly identified as such. Missouri has indicated that failure to have chlordane for both soil and foliar application on strawberries would have a serious effect on production. Several states are recommending foliar applications for pests such as boxelder bug, rhododendron borer, willow tree borer, adult blackvine weevils and magnolia leafminer.

I.C.1.c. Seed Treatments - Most of the recommendations were for corn, other grains, sorghum, and soybeans. The principal insects for which chlordane and heptachlor seed treatments would be recommended include seed corn beetles, seed corn maggots, wireworms and false wireworms. Sorghum seed is also treated to control the kaffir ant.

I.C.1.d. Lawns and Turf - None of the responding states have indicated that they will recommend chlordane as a preemergence herbicide for control of crabgrass on lawns in 1975.

Many states indicated the need for chlordane to control common turf pests, especially white grubs. Such treatments are recommended for home lawns, golf courses, cemeteries, ornamental ground cover, and for use by commercial sod producers.

I.C.1.e. Aquatic Uses - Recommendation of chlordane for mosquito control is limited.

I.C.1.f. Indoor and Outdoor Uses for the Home and Commercial Establishments - The indicated recommendations for this area of chlordane use were many and varied.

I.C.1.g. Structural and Wood Products, Including Termite Control - The pest control industry has estimated that 7,000 firms are engaged in termite control in the United States. A further estimate indicates that 30% of structural pest control revenue is derived from termite control which employs 9,000 direct workers and 4,800 support people who produce $180,000,000 in annual revenue.

Chlordane and/or heptachlor will be recommended in 1975 by most states for termite control. Chlordane was suggested by some states for control of other woodboring insects. Alternative insecticides suggested for control of certain woodboring insects included diazinon, baygon and pentachlorophenol. Several of the states indicated that pentachlorphenol is considered too hazardous and odoriferous for use.

TABLE 1. Chlordane/Heptachlor Usage by State.

State or Territory 1)	Planned recommendations in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (if a difference exists in amounts used in 1973 and 1974 the trend is indicated 2) 3) 4).	
	Chlordane	Heptachlor	Chlordane	Heptachlor
Alabama	X	X	1,000,000 lb	250,000 lb
Alaska	X	X	50 lb	
Arizona	X	X	150,000 lb (down from 1973)	4,000 lb
Arkansas	X	X	no estimate	no estimate
California	X		no estimate	no estimate
Colorado			40 lb (down from 1973)	120 lb (down from 1973)
Connecticut	X		no estimate	no estimate
Delaware	X		no estimate	no estimate
Florida	X	X	1,124,193 lb (1973 estimate - lb sold)	260,367 lb (1973 estimate - lb sold)
Georgia	X		no estimate	no estimate
Guam	X		no estimate	no estimate
Hawaii			126,000 lb (1973)	no estimate
Idaho	X	X	313,000 lb (up from 1973)	no estimate
Illinois	X		715,708 lb (down from 1973)	270,645 lb (down from 1973)
Indiana	X	X	300,000 lb (plus termite and small package use)	300,000 lb (plus termite and small package use)

TABLE 1. (continued)

State or Territory 1)	Planned recommendations in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (if a difference exists in amounts used in 1973 and 1974 the trend is indicated 2) 3) 4).	
	Chlordane	Heptachlor	Chlordane	Heptachlor
Iowa	X	X	75,000 lb (up from 1973)	500,000 lb
Kansas	X		no estimate	no estimate
Kentucky	X		1,000 lb (down from 1973)	no estimate
Louisiana	X		no estimate	no estimate
Maine	X		slightly more than 2,700 lb (up from 1973)	low - no specific estimate
Maryland	X		770,000 lb (70% for termites) (down from 1973)	61,000 lb (down from 1973)
Michigan	X		no estimate	231.3 lb (1973 use)
Minnesota	X	X	160,000 lb (1973 use) (does not include use by PCOs for homeowners, or use on turf)	20,000 lb
Mississippi	X	X	448,520 lb (up from 1973)	258,960 lb (up from 1973)
Missouri	X	X	no estimate	no estimate
Nebraska	X	X	100,000 lb	25,000 lb
Nevada	X	X	8,758 gal. (1973 use)	1,601 gal. (1973 use)
New Hampshire	X		no estimate	none used

TABLE 1. (continued)

State or Territory 1)	Planned recommendations in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (if a difference exists in amounts used in 1973 and 1974 the trend is indicated 2) 3) 4).	
	Chlordane	Heptachlor	Chlordane	Heptachlor
New Mexico	X	X	5,000 lb	500 lb
New York	X (ant only)		no estimate restricted use	no estimate - used by N.Y. State Dept. Agr. to control alfalfa snout beetle
N. Carolina	X		1,750,000 lb (up from 1973) (1,000,000 lbs of this total used on termites)	75,000 lb (down from 1973)
N. Dakota	X	X	79,600 lb (up from 1973)	1,900 lb (down from 1973)
Ohio	X		no estimate	no estimate
Oklahoma	X	X	no estimate	no estimate
Oregon	X		no estimate	no estimate
Pennsylvania			no estimate	no estimate
Puerto Rico	X	X	no estimate	no estimate
S. Carolina	X		no estimate	no estimate
S. Dakota	X	X	no estimate	no estimate
Tennessee	X	X	no estimate	no estimate
Utah	X		5,000 lb	1,000 lb
Vermont	X	used by permit only - no permits issued in 1973 or 1974.	1,600 lb (licensed applicators only - does not include formulations under 10% sold by outlets with no records of sale) (up from 1973)	0

TABLE 1. (continued)

State or Territory 1)	Planned recommendations in 1975 for uses other than termites and dipping of nursery stock		Total poundage used in 1974 (if a difference exists in amounts used in 1973 and 1974 the trend is indicated 2) 3) 4).	
	Chlordane	Heptachlor	Chlordane	Heptachlor
Virginia	X		no estimate	48 lb (1973 use)
Washington	X	X	340,700 lb (lb sold - up more than tenfold from 1973)	no estimate
W. Virginia	X		no estimate	no estimate
Wisconsin	X	X	no estimate	no estimate
Wyoming	X		no estimate	no estimate

(1 As of the date of issuance of this report, replies had not been received from: California, Kansas, Massachusetts, Montana, Rhode Island, Texas.

The state of California, however, has entered as an intervenor in the public hearing to be held on continued registration of heptachlor and chlordane products. In connection with the filing of objections to the cancellation, the California State Department of Agriculture listed a number of sites and pests for which they requested the retention of chlordane. It has therefore been presumed that these compounds will be recommended in 1975, and this has been noted in Table 1. The state of Kansas submitted a list of probable 1975 recommendations in response to a telephone inquiry from this office, and this information has also been included.

2) Many of those responding indicated that data were lacking to support substantive estimates of actual poundages used in their states. Several state representatives stated that estimates were imprecise. States requiring permits for chlordane and heptachlor use would likely have accurate records of amounts sold.

3) Usage of these chemicals may increase in the wake of the manufacturing suspension of aldrin and dieldrin.

4) There is the possibility that several states showing high poundages used or sold in their state have listed pounds of formulated insecticide rather than pounds of actual insecticide.

Chapter II

Toxicity, Fate and Implications of Chlordane and Heptachlor in the Environment

II.A. The Fate of Chlordane in Soil - Stewart and Chisholm (1971) found alpha and gamma chlordane to be the major components of the pesticide residue in Nova Scotia sandy loam soil. Heptachlor was reported to be a minor component of this residue. The last application was made 15 yr previously at a rate of 5 ppm for 15.2 cm depth per hectare per year (equivalent to about 12.5 lb active ingredient/acre) for 3 yr. The amount of residue remaining was estimated to be 16% based on a standard said to be similar in composition to the pesticide originally applied.

The residue from high-purity chlordane (Velsicol HCS-3260) was studied by Wilson and Oloffs (1973) for 16 months following applications to British Columbia soils at rates of 5.6 and 11.2 kg active ingredient per hectare (equivalent to 5 and 10 lb active ingredient/acre). Metabolites and minor components of HCS-3260 occurred at very low concentrations in both moist and dry soil conditions. In addition to alpha- and gamma-chlordane, these were: heptachlor, gamma-chlordane, Compound K, photo-alpha-chlordane, heptachlor epoxide and oxychlordane, amounting to 2.7 - 2.9% of the sum of alpha- plus gamma-chlordane initially, under dry soil conditions, which over a period of 3 months, increased to 6.6%. This increase resulted from the formation of photo-alpha-chlordane which alone accounted for 60% of the total metabolites and minor components after that interval. The total number of metabolites and minor components decreased during this same interval under moist soil conditions. Oxychlordane was not detected under dry soil conditions, although the aerial tissue of alfalfa grown in that soil contained oxychlordane (and photo-alpha-chlordane).

II.A.1. Build-up and Persistence of Chlordane in Soil - Additional investigations on the duration and extent of soil contamination under either experimental or field conditions have been made.

Indicative of the residues in soil are the data tabulated below. Table 1 is from Edwards (1973) with more recent data given as Table 1 (Addenda).

Chlordane is still commonly found in soil. Its persistence and relative persistence remain essentially as indicated previously in this section of the report. The view that chlordane is relatively immobile in soil is confirmed. (Stewart and Chisholm, 1971; Wilson and Oloffs, 1973).

The specialized use of chlordane for termite control includes high rates of application and often some degree of protection from the weather. Thus, it is not surprising to find a report of persistence, such as that of Bennett et al. (1974), in which 15% of the original post-construction application remained 21 yr after treatment (with 4 gal/5 linear ft of a 2% chlordane emulsion). Under the ambient conditions of use in this study, the horizontal and vertical movements were so restrictive that the authors considered environmental contamination not to be a problem.

TABLE 1. Residues of Chlordane in Soil

Location	No. of Sites or Samples	Cropping	Residue (ppm) Max.	Mean	Reference
US	30	Orchard fruits	-	0.10+	Stevens et al.(1970)
US	227	City garden products, and turf	37.60	0.81	Fahey et al.(1965)
			120.0	1.51	
US	41	Vegetables	3.91	0.12	Saha and Sumner(1971)
US	27	Soybeans	1.11	0.24	USDA (1968)
Canada	11	Vegetables	0.86	0.12	Duffy and Wong(1967)
Canada	3	Vegetables	0.11	0.04	Harris and Sans(1969)
US	12	Corn	0.02	0.02	Gish (1970)
US	5	Forage	0.05	0.03	Mullins et al. (1971)
US	92	Sweet potatoes	5.07	0.28	Sand et al. (1972)
US	1729	Mixed	6.30	0.04	Wiersma et al.(1972b)
US	71	Onions	23.84	1.63	Wiersma et al.(1972a)

+ Residues found at only one site

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Addendum to Table 1

Location	No. Times Detected/ Total Samples	Cropping	Residue (ppm) Max.	Mean	Reference
US	36/399	Corn	4.30	0.05	Carey et al.(1973)
US	6/20	Pasture	0.076*	ND*	McLane et al.(1971)
Canada	18/48	Mixed	0.63**	0.16**	Harris and Sans (1971)
US	13/242	Mixed	0.02	0.01	Wiersma et al.(1971)
US	142/399	Garden crops and lawns	20.48	ca 0.7	Wiersma et al. (1972c)
US	162/1506	Mixed	13.34	0.08	Crockett et al. (1974)

* Alpha-chlordane
** Gamma-chlordane
ND None detectable

II.A.2. Translocation into Plants - Data presented previously indicate that when chlordane is applied to soil it will translocate to certain crops, primarily the root crops. Further, it has been indicated that the relationship of the residue in soil to that in the crop is neither consistent nor predictable.

Gutenmann et al. (1972) showed that low levels of chlordane are not translocated into field corn from silt loam soils in central New York State.

II.B. Chlordane in the Atmosphere - It has been suggested that a major transport route of organochlorine insecticides to the oceans involves the atmosphere. Abbott et al. (1965) suggested that these pesticides reside in the atmosphere as vapors or are occluded on dust particles, and, according to Bevenue et al. (1972), "scrubbed out" by rain and snow. There is support for these views in reports of the presence of these substances in air, rainwater and dust, although there are few such reports for chlordane. Data on these reports have been tabulated by Edwards (1973) in part of his Table 6, reproduced here as Table 2.

TABLE 2. Chlordane in the Atmosphere

Location	No. of Sites	Medium	Residue (ppt) Max.	Mean	Reference
US	6	Air	0.006	0.002	Tabor (1966)
US	1	Air	0.03	0.016	Tabor (1966)
Hawaii	11	Rainwater	3.0	1.0	Bevenue et al. (1972)
US	1	Dust deposited by a trace of precipitation	NA	500,000	Weibel et al. (1966)

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Data not previously discussed in the report include a study by Bevenue et al. (1972) on organochlorine pesticides found in rainwater falling on Oahu in 1971-1972. The levels for chlordane ranged from N.D. (none detectable) to 3 ppt.

Bidleman and Olney (1974) reported on the presence of chlordane in marine air from Bermuda, at sea en route from Bermuda to Narragansett, R.I., and in continental air from Providence, R.I. The levels were: <0.005-0.012 ng/m^3 (Bermuda), 0.039-0.17 ng/m^3 (at sea), and 0.25 ng/m^3 (Providence).

In this study a glass fiber filter was found to trap 98% of the particles of chlordane with radii greater than 0.15 μm. However, most of the chlordane was found trapped in a polyurethane foam filter, which traps smaller particles of vapor. Thus, it is suggested that chlordane and chlorinated insecticides reside in the atmosphere as vapors or that they volatilize from particulate matter.

II.C. Chlordane in Surface Water - The behavior and distribution of persistent chlorinated insecticides in the marine environment is such that these substances accumulate in the oceans after having been transported there from the points of application. With modifications this applies to chlordane.

The routes of entry to oceans are considered to be: (1) volatilization of these substances into the atmosphere and "scrubbing out" by rain and snow into the oceans; and, (2) by surface runoff, sewage outfalls and rivers to the oceans.

Oloffs et al. (1972) performed a series of experiments with natural British Columbia waters treated with 0.025 ppm alpha- or gamma-chlordane. The waters were incubated for up to 12 weeks at the temperatures recorded when water samples were taken (7°, 9° and 16°C). These investigations indicated that large proportions of both isomers are transported into the atmosphere. Heptachlor, heptachlor epoxide, oxychlordane and photocis-chlordane were sought, but not found. While the solubilities of the isomers are not known, it was suggested that if these isomers occur in natural water at less than their solubilities, they will be evenly distributed and their rate of transport from water will be lower and about proportional to the evaporation rate of water, for example, they will codistill. However, when the isomers occur in natural water at or above maximum solubility, they appear to accumulate at the water-air interface from which they may evaporate into the atmosphere. Surfactants will counteract evaporation as well. The ready escape into the atmosphere of highly insoluble and chemically stable chlorinated hydrocarbon compounds is said not only to explain their global distribution, but also to indicate that the accumulation which has resulted from their extensive use is unlikely to be reduced so long as their use is curtailed only in some parts of the world and continued or increased in others.

Oloffs et al. (1973) performed a second series of experiments with natural British Columbia waters in the presence of their natural bottom sediments. Waters were treated with 0.025 ppm alpha- or gamma-chlordane and then incubated for up to 12 weeks at 13°C. These investigations indicate that all detectable residues will move from the water into the underlying sediment after 6 and 12 weeks, and demonstrate the influence of bottom sediments on the fate and behavior of these isomers in natural waters. The authors concluded that: "The results of this investigation suggest that a priori conclusions regarding the quantities of persistent chlorinated hydrocarbons present in the open ocean environment may well be misleading if based on levels found or quantities manufactured and used elsewhere. For instance, residues found in a river near an intensely farmed area may partition into bottom sediments or be metabolized instead of reaching the marine environment. On the other hand, residues originating from city sewage outfalls, together with detergents may well present a problem."

Data on the concentrations found in water have been tabulated by Edwards (1973) (reproduced here as Table 3). More recent data are included as Table 3 (Addenda).

TABLE 3 Chlordane Concentrations in Water

Location	No. of Sites or Samples	Types of Water	Residue (ppt) Max.	Mean	Reference
US	109	Major rivers	75.0	0.1	Green et al. (1966)
Hawaii	101	River and drinking water	13.0	7.0	Bevenue et al. (1971)

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Addendum to TABLE 3

Location	No. of Sites or Samples	Types of Water	Residue (ppt) Max.	Mean	Reference
Sargasso Sea	8	Surface and subsurface water	1	-	Bidleman and Olney (1974)
Hawaii	9	Nonpotable	17.6	9.1	Bevenue et al. (1972)
	45	Potable	5.0	1.0	
Canada	3	River	21*	-	Miles and Harris (1973)

* Gamma-chlordane

Schulze et al. (1973) presented data from a U.S. Geological Survey program for monitoring pesticides in the streams of the Western United States for the period October 1968 to September 1971. There was one occurrence of chlordane during the period.

The termite use of chlordane was implicated in two incidents involving contamination by chlordane of farmstead water supplies (Jones, 1973). Both of these incidents were associated with poor well construction. Preliminary

results of the project "Pesticides in Farmstead Water Supplies in the Northeast" indicated that normal agricultural pesticide applications did not appear to endanger most farmstead water supplies. Pesticides were found in low concentrations ranging from approximately one-tenth of the maximum limits of United States Public Health Service drinking water recommendations for long-term ingestion (3 µg/l) to the lower limit of detection of about 0.01 ppb. The extreme variations at the lower concentrations were attributed to atmospheric contamination during sampling.

II.D. The Fate of Heptachlor in Soil - Sethunathan (1973) observed that until recently, attention has usually been given to the fate of organic pesticides in nonflooded soils under aerobic and temperate environments. On this basis, heptachlor has been designated persistent. He recommends that consideration should also be given to flooded soils since such soils are used in the cultivation of rice, a staple food of much of the world's population. Under these circumstances the rate and mechanism of degradation of the insecticide may differ. Heptachlor is rapidly metabolized in flooded soil. Its metabolite, heptachlor epoxide, was not detected. Previous studies had shown that heptachlor epoxide would be formed from heptachlor in aerobic nonflooded soil. Chlordane is stable under both these conditions for three months. (Castro and Yoshida, 1971).

II.D.1. Build-up and Persistence of Heptachlor in Soil - Indicative of the heptachlor or heptachlor epoxide residues in soil are the data tabulated by Edwards (1973). See a portion of his Table 2, reproduced here as Table 4. More recent data are given as Table 4 (Addenda).

II.D.2. Translocation of Heptachlor to Plants - Additional data confirming the absorption and translocation of heptachlor and heptachlor epoxide in plants from soils are given by Dorough and Pass (1972), Gutemann et al. (1972), and Polizu et al. (1971) for corn; Turner et al. (1972) for soybeans; and, Kawahara and Nakamura (1972) for turnips.

II.E. Heptachlor and Heptachlor Epoxide in the Atmosphere - Indicative of the residues which may occur are the data tabulated by Edwards (1973). See portion of his Table 6, reproduced as Table 5.

II.F. Heptachlor and Heptachlor Epoxide in Surface Water - Indicative of the residues which may occur in surface water are the data tabulated by Edwards (1973). See portions of his Table 8, reproduced here as Table 6. More recent data are given as Table 6 (Addenda).

II.G. Residues and Effects in Aquatic Systems

II.G.1. Residues of Chlordane and Heptachlor in Sediments - Levels of chlordane and heptachlor much higher than water residue concentrations have frequently been reported. Sediment concentrations of up to 30,000 ppm chlordane and 1090 ppm heptachlor have been recorded in Tennessee.

TABLE 4. Residues of Heptachlor and Heptachlor Epoxide in Soil

Location	No. of Sites or Samples	Cropping	Residues (ppm) Max.	Mean	Reference
Canada	6	Orchard fruits	0.02	T	Duffy and Wong (1967)
US	227	City garden products and turf	1.23	0.03	Fahey et al. (1965)
US	6	Vegetables	T	T	Mullins et al. (1971)
US	41	Vegetables	0.34	0.03	Saha and Sumner (1971)
US	19	Carrots	0.26	0.16	Seal et al. (1967)
US	27	Soybeans	0.16	0.02	USDA (1968)
Canada	11	Vegetables	1.39	0.16	Duffy and Wong (1967)
Canada	3	Vegetables	0.17	0.06	Harris and Sans (1969)
Canada	11	Vegetables	0.20	0.02	Harris et al. (1966)
US	12	Corn	0.03	0.004	Gish (1970)
US	3	Rice	0.02	-	Gish (1970)
US	5	Forage	0.07	0.05	Mullins et al. (1971)
US	11	Grain	-	0.02+	Mullins et al. (1971)
US	10	Mixed	-	T	Mullins et al. (1971)
US	92	Sweet potatoes	0.39	0.02	Sand et al. (1972)

TABLE 4. Residues of Heptachlor and Heptachlor Epoxide in Soil (continued)

Location	No. of Sites or Samples	Cropping	Residues (ppm) Max.	Mean	Reference
US	25	Potatoes	0.10	0.08	Seal et al. (1967)
US	41	Mixed	0.01	T	Trautmann (1968)
US	1729	Mixed	1.08	0.01	Wiersma et al. (1972b)
US	71	Onions	2.24	0.09	Wiersma et al. (1972a)

+ Residues found at only one site.

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Addendum to Table 4.

Location	No. Times Detected/ Total Samples	Cropping	Combined Residues (ppm) Max.	Mean	Reference
US	6/20	Pasture	0.118*	ND*	McLane et al. (1971)
US	58/399	Corn	1.15	0.03	Carey et al. (1973)
Canada	19/48	Mixed	0.50	0.16	Harris and Sans (1971)
US		-	1.06	0.06	Wiersma et al. (1972c)
US	245/1506	Mixed	2.05	0.02	Crockett et al. (1974)

* Heptachlor epoxide only
ND None detectable
T Trace

TABLE 5. Heptachlor and Heptachlor Epoxide Residues in Air, Rainwater, and Dust

Location	No. of Sites or Samples	Concentration (ppt) Max.	Mean	Reference
US	9 Air (cities)	0.019	-	Stanley et al. (1971)
US	1 Dust (deposited by a trace of precipitation)	-	40,000	Weibel et al. (1966)

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TABLE 6. Concentrations of Heptachlor and Heptachlor Epoxide in Water

Location	No. of Sites or Samples	Types of Water	Concentration (ppt) Max.	Mean	Reference
W. Germany	51	Major Rivers	2000.0	39.4	Herzel (1970)
US	10	Mississippi River	10.0	2.0	USDA, ARS-81-13 (1966)
US	13	California Rivers	0.15	0.017	Bailey and Hannum (1967)
US	7	California Bays	0.15	0.016	Bailey and Hannum (1967)
US	6	Calif. Agr. Drains	0.04	0.008	Bailey and Hannum (1967)
US	99	Major River Basins	155.0	6.3	Breidenbach et al. (1967)

TABLE 6. Concentrations of Heptachlor and Heptachlor Epoxide in Water (continued)

Location	No. of Sites or Samples	Types of Water	Concentration (ppt) Max.	Mean	Reference
US	11	Major Rivers (west)	90.0	2.6	Brown and Nishioka (1967)
US	109	Major Rivers	19.0	0.1	Green et al. (1966)
US	82	Calif. Water Areas	T*	T*	Keith and Hunt (1969)
US	20	Streams (west)	60.0	1.4	Manigold and Schulze (1969)
US	48	Water Areas	15,800.0	-	Weatherholtz et al. (1967)

*T = Trace

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Addendum to Table 6

Location	No. of Sites or Samples	Concentration (ppt) Max.	Mean	Reference
Hawaii	45	ND*	-	Bevenue et al. (1972)
West Germany	28	205	-	Herzel (1972)
Netherlands	-	60	10	Greve (1972)
US	16	200	-	Bradshaw et al. (1972)

*ND = None dectectable

(Barthel et al., 1969). Chlordane was found in 92% of the sediments taken from tributaries of San Francisco Bay with a maximum concentration reported at 800 ppb (Law and Goerlitz, 1974).

Marsh sediments in Rhode Island have been found to contain 363 ppb chlordane. A concentration of 480 ppb chlordane has been recorded for sediments of the Pawtuxent River in the same state (Olney, 1972).

Chlordane residues have been reported in the sediments of nonpotable waters in Oahu, Hawaii with the maximum reported level being 720 ppb (Bevenue et al. 1972).

II.G.2. Effects on Aquatic Life - Both chlordane and heptachlor have been shown to be toxic to aquatic life at low concentrations (Table 7).

Levels of maximum acceptable toxicant concentration (MATC) for chlordane and heptachlor have been determined from chronic exposure tests with several species of aquatic animals (Table 8) (Cardwell et al., in press; and Macek et al., in press).

Low levels of both of these compounds (0.01 ppm) have been shown to inhibit oyster growth (Butler et al., 1960). A 1.0 ppm solution of heptachlor caused the barbels of catfish (Heteropneustes fossilis) to curl, with death occurring after 44 hr (Konar, 1969). Exposure of bluegills (Lepomis macrochirus) to this same concentration of heptachlor (1.0 ppm) resulted in severe hemorrhaging in the pelvic and pectoral fins (Phelps et al., 1964). Rainbow trout gill microsomal ATPase activity was inhibited by 4 ppm chlordane (77%) and by 4 ppm heptachlor (67%) (Davis, 1972).

The photoproduct of heptachlor, photo-heptachlor, has been shown to be more toxic to minnows (Georgakis and Kahn, 1971) than to Daphnia, amphipods, and isopods (Khan et al., 1973). Photochlordene is less toxic to Daphnia and bluegills (Lepomis macrochirus) than is the parent chlordene (Khan et al., 1973).

II.G.3. Residues in Natural Environments - Chlordane, heptachlor and heptachlor epoxide residues are widespread in fish. Residues of 8.33 ppm heptachlor in white perch (Morone americanus), 6.93 ppm heptachlor epoxide in large mouth bass (Micropterus salmoides), and 2.24 ppm chlordane in the pumkinseed (Lepomis gibbosus), have been found during the National Pesticide Monitoring Program. Heptachlor and/or heptachlor epoxide were found in 32% of the samples while chlordane was reported 22% of the time (Henderson et al., 1969). Residues of 1.55 ppm heptachlor and 0.56 ppm heptachlor epoxide have been reported in the muscle of winter flounder, Pseudopleuronectes americanus (Smith and Cole, 1970). Heptachlor and chlordane residues have been reported in excess of 0.01 ppm in fish from Canadian rivers (Miles and Harris, 1973).

TABLE 7. Toxicity of Chlordane and Heptachlor to Aquatic Animals

Species	Concentration (ppb) Chlordane	Heptachlor	Test	Source
Chinook salmon (*Oncorhynchus tshawytscha*)	57.0	-	96-hr. LC_{50}	Cardwell *et al.*, in press
Bluegill (*Lepomis macrochirus*)	16.5	-	96-hr. LC_{50}	Cardwell *et al.*, in press
Sheepshead minnow (*Cyprinodon variegatus*)	24.5	3.68	96-hr. LC_{50}	pers. com. Gulf Breeze NERC (1974)
Pinfish (*Lagodon rhomboides*)	6.4	3.77	96-hr. LC_{50}	pers. com. Gulf Breeze NERC (1974)
Fathead minnow (*Pimephales promelas*)	52.0	78.0	96-hr. LC_{50}	Henderson et al. (1959)
Scud (*Gammarus fasciatus*)	40	56	96-hr. LC_{50}	Sanders (1972)
Glass shrimp (*Palaemonetes kadiakensis*)	10	1.80	96-hr. LC_{50}	Sanders (1972)
Crayfish (*Orconectes nais*)	-	7.8	96-hr. LC_{50}	Sanders (1972)
Pink shrimp (*Peneus duorarum*)	0.4	0.1	96-hr. EC_{50}	pers. com. Gulf Breeze NERC (1974)

TABLE 8. Chronic Toxicity of Chlordane and Heptachlor to Aquatic Animals

Species	Maximum Acceptable Toxicant Concentration (ppb)	
	Chlordane	Heptachlor
Bluegill (Lepomis macrochirus)	0.54-1.22	-
Fathead minnow (Pimephales promelas)	0.75-1.38	1.2
Brook trout (Salvelinus fontinalis)	0.36	-
Chironomus 51	0.7	-
Daphnia magna	12-25	12.5

Source: Cardwell et al. (in press) and Macek et al. (in press).

A metabolite of heptachlor, 1-hydroxychlordane, has been found with residue concentrations greater than 0.01 ppm in at least eight species of fish in Iowa (Bondeman and Slach, 1972). In this same study residues of heptachlor and heptachlor epoxide were frequently noted.

The ability of chlordane and heptachlor epoxide to pass from gravid female fish to their eggs was documented by Johnson and Morris (1974). Eggs taken from gravid channel catfish (Ictalurus punctatus) and northern pike (Esox lucius) contained up to 350 ppb chlordane. Eggs taken from channel catfish, northern pike, walleyes (Stizostedion vitreum), and largemouth bass (Micropterus salmoides) had from 5 to 93 ppb heptachlor epoxide.

In sampling fish from ponds and rivers in Rhode Island, Olney (1972) frequently found chlordane residues, with some greater than 200 ppb. Hydroxychlordane residues were also reported.

Godsil and Johnson (1968) analyzed water, vascular plants, algae, chubs (Siphateles spp.), clams, and largemouth bass taken from the Tule Lake National Wildlife Refuge. With water concentrations in the 10's of ppt chlordane range, the plants and animals were found to have accumulated chlordane residues in the 10's of parts per billion range. Hannon et al. (1970) reported heptachlor - heptachlor epoxide residues in the Lake Poinsett, South Dakata ecosystem. Average values (ppb) were: water, .006; bottom sediment, 0.8; crayfish, 1.0; plankton-algae, 1.1; fish, 8.0; and aquatic insects, 312.

These residues found in organisms where the water concentrations of chlordane and heptachlor are extremely minute indicate that biological concentration of these pesticides is an area of environmental interest.

II.H. Toxicity and Effects on Wildlife

II.H.1. Acute Toxicity to Birds - The relative dietary toxicities of 89 pesticides to four species of birds (bob-white, Japanese quail, pheasant and mallard) have been determined by Heath et al. (1972), using dieldrin as a standard. The LC_{50} for chlordane ranged from 331 to 858 ppm in 5-day feeding tests while that for heptachlor was 92-480 ppm. Roughly, dieldrin was from 2 to 4 times more toxic than heptachlor and from 4 to 8 times more toxic than chlordane.

II.H.2. Residues in Wildlife - Recent analyses indicate that oxychlordane, a metabolite of chlordane, occurs frequently in starlings (Paul R. Nickerson, personal communication, February 19, 1975) and bald eagles (William L. Reichel, personal communication, February 19, 1975). Residues of heptachlor epoxide are relatively widespread in wildlife but at generally low levels. Maximum levels reported from wide surveys are 7.9 ppm lipid basis for breast muscle in mourning doves (Kreitzer, 1974), 0.16 ppm in eggs of black duck (Longcore and Mulhern, 1973), 8.67 ppm for breast muscle (lipid basis) in woodcock (Clark and McLane, 1974), and 0.97 ppm in starling pools (Martin and Nickerson, 1972). For mallard and black duck wings: "Heptachlor epoxide was detected in most pools and in every state except Vermont. Few pools contained levels exceeding 0.02 ppm ..." (Heath and Hill, 1974). Specific reasons for occasional high levels are not known but in starlings relatively high levels (0.1 ppm or greater) were consistently associated with the corn belt and the southern states from Louisiana to the Florida panhandle.

Other surveys have been more local in scope. Three years after discontinuing aerial treatment with heptachlor for fire ant "eradication" in Louisiana, heptachlor epoxide residues in woodcock averaged 0.15 ppm wet weight and ranged up to 0.62 ppm (McLane et al., 1971). Greenberg and Edwards (1970) found maximum levels of 0.40 ppm heptachlor epoxide in eggs of wild pheasants in Illinois in 1966. In 4 of 25 clutches the mean was 0.1 ppm or greater. Anderson et al. (1970) found heptachlor epoxide in 757 of 147 pheasants collected in Illinois with the highest value for subcutaneous fat being 4.76 ppm. Eggs of the little blue heron in southeast Missouri contained up to 0.15 ppm heptachlor epoxide with a mean of 0.011 ppm in 1967 but none detected in 1968 (Greenberg and Hege, 1971). Johnson (1974) found up to 0.012 ppm heptachlor epoxide in composite samples of fat from mallards and from 0.011 to 0.019 ppm in similar samples of other species of migrating ducks in Iowa. Verler and Reynolds (1970) found up to 0.9 ppm heptachlor epoxide in mallard eggs

(composite sample of 10) in the prairie provinces of Canada while values for other aquatic birds ranged from maximum of 0.246 ppm in ring-billed gulls to a maximum of 0.023 ppm in the white pelican. They suggested that specific differences in residue values were related to food habits.

Twenty of 35 mink collected in Iowa had detectable residues of heptachlor epoxide ranging up to 0.2 ppm in the adipose tissue but no residues were detected in liver and brain (Franson et al., 1974). Boddicker et al. (1971) reported an average of 0.12 ppm heptachlor epoxide in the renal fat of mountain goats in South Dakota. This exceeded levels previously found in deer and pronghorn antelope, and the contrast was unexpected because of the more remote habitats of the goats. Twenty-five of 45 pronghorns had heptachlor epoxide residues at or above the level of detection (0.03 ppm) and the highest value was 0.12 ppm (Moore et al., 1968). Robel et al. (1972) found relatively low heptachlor epoxide residues (0.001-0.02 ppm) in rodents associated with an experimental area treated with about 0.5 lb heptachlor/acre but the extent to which the rodents actually fed in the treated area was unknown.

II.H.3. Mortality in the Field - In recent years, dramatic wildlife kills have not been attributed to the major uses of these pesticides in the United States. Past reports of kills have been associated primarily with the use of heptachlor in eradication programs for insects such as the fire ant. Such special uses, however, attract the attention of biologists and more common uses, such as for seed dressing, bear investigation.

When heptachlor, aldrin and dieldrin were used as seed dressings on spring-sown cereal grains in the United Kingdom, casualties among granivorous birds occurred on a large scale. This led to a voluntary ban on such uses (Papworth, 1971). Similarly, an official ban on the use of aldrin, dieldrin and heptachlor for spring-sown grains in the Netherlands (January 1, 1968) was extended to include fall-sown seed following a widespread mortality of raptors in the winter of 1968-1969. Dieldrin residues then declined by about an order of magnitude in certain raptors over the next two years (Fuchs, 1972). In North America, the use of aldrin and heptachlor as seed dressings for cereal grains in the prairie provinces of Canada was directly linked to highly significant increases in residues found in seed eating birds and mammals. These prey species were considered to be the major sources of residues found in prairie falcon (heptachlor epoxide max = 7.04 ppm) and merlin eggs (heptachlor epoxide max = 4.63 ppm) and led to the recommendation that these uses of aldrin and heptachlor be suspended as of January 1, 1974 (Fyfe, 1973). Except for the use of aldrin on rice seed (Flickinger and King, 1972), comparable information appears to be lacking for the United States.

II.H.4. Effects on Raptors - From the viewpoint of hazards to wildlife, the possible effects on certain raptors is of greatest concern. Analyses of 169 golden eagles found dead or incapacitated from 1964-1971 yielded generally low values in 32 specimens positive for heptachlor epoxide in fat (2.4 ppm maximum) (Reidinger and Crabtree, 1974). One of seven brain positives was 2.3 ppm, which approaches the range where acute effects can be suspected. Bald eagles, similarly collected in 1969 and 1970 had a higher prevalence of residues (31 of 39) but values were relatively low (Trace amount to 0.41 ppm heptachlor epoxide in carcass) (Belisle et al., 1972). Heptachlor epoxide was also found in the eggs of bald eagles in 1969-1970, with the highest value (0.17 ppm) being from Minnesota (Wiemeyer et al., 1972). Effects, if any, of these residues cannot be determined because they are generally associated with much higher levels of dieldrin and DDT-type compounds. The same can be said for other birds of prey, such as the red-tailed hawk and the great horned owl (Seidensticker and Reynolds, 1971).

II.H.5. Effects on Reproduction - The chronic effects of chlordane and heptachlor on wildlife have not received adequate study. Unpublished results from Patuxent Wildlife Research Center (R.G. Heath, personal communication) indicate no measurable effects on reproduction in bobwhite and mallards. Grolleau and Froux (1973), however, found an increased mortality in Japanese quail chicks when the hen was given 1 mg heptachlor/day. The effect was not satistically significant at lower doses,but a trend may be present. Similar results were obtained from the partridge, Perdix perdix, but the increased mortality of chicks was not statistically significant (Havet, 1973). Such results from studies of precocial birds hatched in incubators provide no information concerning possible effects on the behavior of the adult in caring for the eggs and young and on the ability of precocial young to forage successfully in the field.

CHAPTER II

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CHAPTER III

Residues of Chlordane in Crops and Food Items

III.A. Tolerances - The existing tolerances for residues of chlordane in or on raw agricultural commodities are listed in 40 CFR 180.122.

The interim tolerances listed in 40 CFR 180.319 are also in effect until action is completed on certain petitions (PP No. 1F1041 and FAP Nos. 1H2600 and 3H5026) submitted by the Velsicol Chemical Corporation.

Copies of these sections of the regulations are reproduced here in Exhibit 1.

The Food and Drug Administration, HEW, and the Animal and Plant Health Inspection Service, USDA, maintain action levels for residues of chlordane.

III.B.1. Residues in Vegetable Crops - Additional published data on the amount of the residues in crops is shown in Table 1.

TABLE 1. Residues of Chlordane in Crops.

Crop	Source of Residue	Source	Residue (ppm) Crop	Reference
Alfalfa	soil	0.25	75.60+	Dorough et al. (1972)
Corn	soil	0.053	<0.008*	Guntemann et al. (1972)
Corn (silage stage)	soil	ca 0.18	0.034**+	Dorough et al. (1972)
Corn (grain, cob)	soil	ca 0.17	<0.008**+	Dorough et al. (1972)
Corn (stalk)	soil	ca 0.17	0.020**+	Dorough et al. (1972)
Soybeans	soil	0.020	<0.0001	McCaskill et al. (1970)
Sugar beets	soil	1.233	0.224	Onsager et al. (1970)
Sweet potatoes	soil	0.28	0.001	Sand et al. (1972)
Wheat (foliage)	seed treatment	44.0	0.003	Burrage and Saha (1967)

* As gamma-chlordane
** As alpha-plus gamma-chlordane
\+ High-purity chlordane (HCS-3260) used.

Source: Reprinted from Persistent Pesticides in the Environment, 2nd ed., by C. A. Edwards by permission of CRC Press, Cleveland, Ohio (1973).

§ 180.122 Chlordane tolerances for residues.

A tolerance of 0.3 part per million is established for residues of the insecticide chlordane (1,2,4,5,6,7,8,8-octachloro-2,3,-3a,4,7,7a-hexahydro-4,7-methanoindene, containing not more than 1 percent of the intermediate compound hexachlorocyclopentadiene) in or on each of the following raw agricultural commodities: Apples, apricots, beans, beets (with or without tops) or beet greens alone, blackberries, blueberries (huckleberries), boysenberries, broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, cherries, citrus fruits, collards, corn, cucumbers, dewberries, eggplants, grapes, kale, kohlrabi, lettuce, loganberries, melons, nectarines, okra, onions, papayas, peaches, peanuts, pears, peas, peppers, pineapples, plums (fresh prunes), potatoes, quinces, radishes (with or without tops) or radish tops, raspberries, rutabagas (with or without tops) or rutabaga tops, squash, strawberries, summer squash, sweetpotatoes, tomatoes, turnips, (with or without tops) or turnip greens, youngberries.

§ 180.319 Interim tolerances.

While petitions for tolerances for negligible residues are pending and until action is completed on these petitions, interim tolerances are established for residues of the listed pesticide chemicals in or on raw agricultural commodities as follows:

Chlordane	0.2 ppm.....	Parsnips
	0.1 ppm.....	Asparagus, mustard greens, pumpkins, spinach and Swiss chard
	0.0 ppm.....	Bananas

EXHIBIT I

Despite differences in the residues of alpha- and gamma-chlordane in the soil, residues of these isomers were comparable in corn (silage stage, grain, cob and stalk) for chlordane and for high-purity chlordane (HCS-3260) (Dorough and Pass, 1972).

The amount of residue in many crops is uniformly low, i.e. about 0.1 or 0.2 ppm, from good agricultural practice. Chlordane tends to concentrate in the crude oils of oil seed crops to levels above those in the original seed, and in the oil seed meal. After refining these levels are lowered (Duggan, 1968).

III.B.2. Residues in Feeds - Chlordane is not used on forage crops. However, it is used on certain crops, parts of which may contain residues, and may be used as forage or fodder and/or derived by-product feed items. In addition, there is the possibility of residues in crops planted subsequently to a crop treated with chlordane as indicated in Section III.B.1.

It may not always be possible to establish tolerances or to impose practical feeding restrictions or otherwise preclude the feeding of residue-bearing forage to livestock. These items therefore are a potentially troublesome source of residues in meat, milk, poultry and eggs.

III.B.3. Residues in Meats, Milk, Poultry, and Eggs - Boyd (1970) conducted tests to determine how much chlordane can be fed to cows to maintain residues in milk below a 0.3 ppm (fat basis) action level. In one study, cows were fed 12 weeks on hay containing an average of 3.5 ppm technical chlordane; the residues reported as heptachlor epoxide, were erratic (0.18 to 1.34 ppm) averaging 0.551 ppm. These residues were not further confirmed, but Boyd (1971) later published a statement that these consisted of only 10% heptachlor epoxide and 90% of a degradation product of chlordane, subsequently identified as oxychlordane.

High-purity chlordane (HCS-3260) was fed to Holstein cows at 1, 10 and 100 ppm once daily for 60 days by Dorough and Hemken (1973). The total HCS-3260 residues in milk fat rose rapidly at the 1 ppm feeding level, total residues leveled off at 0.5 ppm after 10 days. At the 10 and 100 ppm levels, approximately 35 and 45 days were required for a plateau at 2.5 and 5.0 ppm respectively. The major component of the residue in milk fat was identified as oxychlordane, accounting for 70 to 75% of the total residue while the animals were being treated. It accounted for essentially 100% of the total residue in milk fat after HCS-3260 had been removed from the feed for 10 days.

III.C. Pesticide Monitoring

III.C.1. Market Basket Surveys - Surveys conducted by the Food and Drug Administration continue to demonstrate that chlordane is only infrequently found in total diet studies and not at all in the latest available study for the period 1970-71. (Corneliussen 1970, 1972) (Manske and Corneliussen, 1974).

III.C.2. Other Residue Surveys - Chlordane was not among the most frequently detected residues in 4,836 domestic survey samples examined during FY 73 on a national basis by the Food and Drug Administration, particularly for domestic raw agricultural commodities, manufactured dairy products (cheese, butter, etc.), eggs and egg products, processed animal feeds and whole fluid milk. However, chlordane was detected in processed foods (with a relative frequency of 5%) and fish and marine products (with a relative frequency of 2%).

The Animal and Plant Health Inspection Service (and its predecessor, the Consumer and Marketing Service), USDA, found residues of chlorinated hydrocarbon insecticides, including chlordane in samples of fat tissues of livestock and poultry. Occurrences of residues are tabulated in Table 2.

TABLE 2. Occurrences of Residues of Chlordane in Fat Tissue*

Year	No. Samples	No. Samples with Residues	% Samples with Residues	Residue Range (ppm)			
				0.01-0.10	0.11-0.50	0.51-1.50	>1.50
		All Livestock					
1967	2785	11	0.4	2	8	0	1
1968	2698	5	0.2	0	4	1	0
1969	3169	2	0.06	1	1	0	0
1970	3500	2	0.06	0	0	2	0
1971	2403	1	0.04	0	0	0	1
1972	819	0	0	0	0	0	0
1973	1070	7	0.7	4	2	1	0
				0.01-0.30	0.31-1.00	1.01-1.50	>1.50
1974	2256	398	17.7	393	2	1	2
				0.01-0.10	0.11-0.50	0.51-1.50	>1.50
		All Poultry					
1967		No reports					
1968	2659	2	0.08	0	1	1	0
1969	2199	0	0	0	0	0	0
1970	2972	0	0	0	0	0	0

Year	No. Samples	No. Samples with Residues	% Samples with Residues	Residue Range (ppm)			
				0.01-0.10	0.11-0.50	0.51-1.50	1.50
1970	2972	0	0	0	0	0	0
1971	1804	0	0	0	0	0	0
1972	417	0	0	0	0	0	0
1973	1142	7	0.6	0	7	0	0
				0.01-0.30	0.31-1.00	1.01-1.50	1.50
1974	1916	38	2.0	38	0	0	0

* Data calculated in whole or in part from reports made available by Animal, Plant, Health Inspection Service, USDA.

Reinke et al. (1972) found organochlorine pesticide residues in commercially caught fish from a total of 78 locations in 68 central Canadian lakes and rivers. Trace amounts of chlordane and heptachlor epoxide were found in some samples.

Although not considered a food, tobacco was also reviewed. Gibson et al. (1972) conducted a study of the levels of chlorinated insecticides (including chlordane) in Kentucky Burley tobacco produced during the period 1968-1972 but still available for sale. The only residue reported for chlordane was 0.27 ppm, an average for all samples collected during the year 1971. Chlordane appears to be one of the lesser contaminants of Kentucky Burley tobacco.

CHAPTER III

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CHAPTER IV

Residues of Heptachlor in Crops and Food Items

IV.A. Tolerances - The existing tolerances for residues of heptachlor and heptachlor epoxide in or on raw agricultural commodities are listed in 40 CFR 180.104. The list includes a number of zero tolerances whose present status is moot.

The interim tolerances listed in 40 CFR 180.319 are also in effect until action is completed on certain petitions (PP No. OF0935 and FAP No. OH2520) submitted by the Velsicol Chemical Corporation.

Copies of these sections of the regulations are reproduced here in Exhibit I.

A request is pending for an interim tolerance of 0.1 ppm for unavoidable residues in or on pumpkins from the previous use of heptachlor (PP No. 4E1455).

The Food and Drug Administration, HEW, and the Animal and Plant Health Inspection Service, USDA, Maintain action levels for residues of heptachlor and heptachlor epoxide. Data from Table 1 is indicative of the residues which ma occur in crops.

IV.B.2. Residues in Feeds - Heptachlor is not used on forage crops. However, it is used on certain crops, parts of which may contain residues and may be used as forage or fodder and/or derived by-products which may be used as feed. In addition, there is the possibility of residues in crops planted in the same field after a crop treated with chlordane, as indicated in Section IV A.

It may not always be possible to establish tolerances or to impose practical restrictions on feed or otherwise preclude the furnishing of feed to livestock. These items are a potentially troublesome source of residues in meat, milk, poultry and eggs.

Residue data indicate that residues do not concentrate except in oil from oil seeds and soapstock.

IV.B.3. Residue in Meat, Milk, Poultry and Eggs - A number of studies are available to indicate the carry over of residues into meat, milk, poultry and eggs (Huber and Bishop, 1962) (Williams et al., 1964, Cummings et al., 1966, 1967). These studies were conducted at low levels comparable to those which may be ingested by livestock and include a plateau. In general, these studies indicate a consistent concentration factor for the deposition of residues in body fat, in butterfat, and in the fat of eggs. This represents a 10 to 15 fold increase over residues ingested in the dry diet or ration.

TABLE 1. Movement of Heptachlor from Soil into Plants.

Crop	Source of Insecticide	Amount in source (pp 10^6)*	Amount in plant (pp 10^6)*	Conc. or dilution factor**	Reference
Alfalfa foliage	soil	0	0.91	-	Dorough et al. (1972)
Alfalfa foliage	soil	0.234	0.67	2.863	King et al. (1966)
Alfalfa roots	soil	0.234	0.41	1.752	King et al. (1966)
Alfalfa	soil	0.78	0.028	0.036	Lichtenstein & Schulz (1965)
Carrot roots	silt loam soil	1.33	0.98	0.737	Lichtenstein et al. (1965)
Carrot roots	soil	0.49	0.36	0.735	Lichtenstein et al. (1965)
Carrot	sandy soil	0.44	0.039	0.089	Oloffs et al. (1971)
Carrot	muck soil	1.40	0.004	0.003	Oloffs et al. (1971)
Cucumber fruit	soil	3.8	0.091	0.721	Lichtenstein & Schulz (1965)
Lettuce	silt loam soil	2.5	0.04	0.016	Lichtenstein & Schulz (1965)
Oat seed	soil	1.0	0.02	0.02	Bruce et al. (1966)
Potato tubers	soil	0.49	0.05	0.102	Lichtenstein et al. (1968)
Rutabaga roots	soil	0.320	0.024	0.075	Saha and Stewart (1967)
Soybeans	soil	0	0.0005	-	McCaskill et al. (1970)
Soybeans	soil	1.0	0.11	0.11	Bruce et al. (1966)
Sugar beet roots	silt loam soil	2.5	0.14	0.056	Lichtenstein & Schulz (1965)
Sweet potato tubers	soil	0.02	0.0004	0.02	Sand et al. (1972)
Turnips	silt loam soil	2.5	0.09	0.036	Lichtenstein & Schulz (1965)
Wheat foliage	treated soil	543.0	0.015	0.00003	Burrage and Saha (1967)
Wheat	soil	1.94	0.11	0.057	Wingo (1966)
Wheat	soil	0.74	0.44	0.045	Wingo (1966)

* mg/kg

** concentration of dilution factor = $\frac{\text{amount in plant}}{\text{amount in soil}}$

§180.104 Heptachlor and Heptachlor epoxide, tolerances for residues.

Tolerances for total residues of the insecticide heptachlor (1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene) and its oxidation product heptachlor epoxide (1,4,5,6,7,8,8-heptachloro-2,3-epoxy-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene) from application of heptachlor in or on raw agricultural commodities are established as follows:

0.1 part per million in or on cabbage, lettuce, rutabagas, snap beans.

Zero in or on alfalfa, apples, barley, beets (including sugar beets), black-eyed peas, brussels sprouts, carrots, cauliflower, cherries, clover, corn, cottonseed, cowpeas, grain sorghum (milo), grapes, grass (pasture and range), kohlrabi, lima beans, meat, milk, oats, onions, peaches, peanuts, peas, pineapples, potatoes, radishes, rye, sugarcane, sweet clover, sweetpotatoes, tomatoes, turnips, (including tops), wheat.

§ 180.319 Interim tolerances.

While petitions for tolerances for negligible residues are pending and until action is completed on these petitions, interim tolerances are established for residues of the listed pesticide chemicals in or on raw agricultural commodities as follows:

Heptachlor	0.1 ppm	Peppers
	0.2 ppm	Tomatoes
	0.01 ppm	Blackberries, blueberries, boysenberries, dewberries and raspberries.

Exhibit I

Table 2. Heptachlor Epoxide Residues in Total Diet Samples
(Residues in ppm whole commodity basis)

Year	1968-69	1969-70	1970-71	1971-72
I. Dairy Products				
Averages	0.003	0.002	trace	trace
Maxima	0.005	0.005	0.002	0.004
II. Meat, Fish and Poultry				
Averages	0.005	0.006	0.002	trace
Maxima	0.016	0.020	0.011	0.003

The Animal and Plant Health Inspection Service (and its predecessor, the Consumer and Marketing Service), USDA, found residues of chlorinated hydrocarbon insecticides, including heptachlor (and heptachlor epoxide) in samples of fat tissues of livestock and poultry. Occurrences of residues are tabulated below.

IV.C. Pesticide Monitoring

IV.C.1. Market Basket Surveys - Residues of heptachlor epoxide occurred commonly in the two food classes, dairy products and meat, fish and poultry, and infrequently in the other ten classes. Heptachlor per se was rarely, if ever, found. The data from the latest period and for two previous periods were tabulated below for the two forementioned sensitive food classes. This tabulation also includes data obtained verbally from the Food and Drug Administration for the period 1971-72. Because of a change in the manner of reporting data, it was necessary to recalculate the residue values from the previously used fat basis to a whole commodity basis for the periods 1968-69 and 1969-70.

IV.C.2. Other Residue Surveys - Heptachlor epoxide was frequently detected by the Food and Drug Administration in 4,836 domestic survey samples examined during FY 73 on a national basis. (Heptachlor itself was infrequently detected). The frequency of residues was greatest for manufactured dairy products (with a relative frequency of 10%) and whole fluid milk (with a relative frequency of 4%); and least of all for agricultural commodities, eggs and egg products, fish and marine animals, processed animal feeds and processed foods (Food and Drug Administration, 1973).

IV.D. Removal of Residues - The effects of cooking and heating on residues of chlorinated hydrocarbons, including, heptachlor in poultry were investigated by Ritchey et al. (1972). Heptachlor was fed to broilers at 10 ppm for 8 weeks, which when slaughtered contained 28.1 ppm. (All values are in terms of heptachlor epoxide in dry tissue, and because of variations, are reported as means). Baking reduced the residue to 22.5 ppm; steaming to 22.1 ppm; frying, not at all. Heating in a closed container at 350°F for 30, 60 and 90 min reduced the residue to 16.0-19.5 ppm, with no losses after 30 min.

The elimination of chlorinated hydrocarbon residues, including heptachlor, was studied by Vioque et al. (1973). Using virgin olive oil fortified with 1 ppm heptachlor, these workers observed that deodorization by passing steam through the oil at 180°C for 3 hr resulted in partial removal of the heptachlor; at 210°C for 3 hr, more extensive removal and at 240°C for 3 hr, complete removal. Neutralization and decolorization were ineffective for heptachlor.

TABLE 3. Occurrences of Residues of Heptachlor (and Heptachlor Epoxide) in Fat Tissue* (ppm)

Year	No. Samples	No. Samples w/ Residues	% Samples w/ Residues	0.01-0.10	0.11-0.50	0.51-1.5	1.50
			All Livestock				
1967	2785	829	29.8	759	65	2	3
1968	2698	746	27.8	628	109	8	1
1969	3169	752	23.8	637	114	0	1
1970	3500	997	28.6	887	107	2	1
1971	2403	259	10.8	237	21	1	0
1972	819	45	5.5	43	2	0	0
1973	1070	206	19.3	188	18	0	0
1974	2114	540	24.0	536	3	0	1
				0.01-0.10	0.11-0.50	0.51-1.50	1.50
			All Poultry				
1967		No reports					
1968	2659	803	30.1	687	113	3	0
1969	2199	313	14.2	276	36	1	0
1970	2972	865	29.2	728	133	4	1
1971	1804	271	15.0	248	22	1	0
1972	417	39	9.4	39	0	0	0
1973	1142	123	10.8	115	8	0	0
				0.01-0.30	0.31-1.00	1.01-1.50	1.50
1974	1916	250	13.1	249	1	0	0

* Data claculated in whole or in part from reports made available by Animal Plant Health Inspection Service, USDA.

CHAPTER IV

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CHAPTER V

Toxicology and Epidemiology of Chlordane

V.A. Introduction - A survey of the literature available on chlordane since the Review of 1972 has revealed some ne information relative to its carcinogenic, mutagenic, teratogenic, metabolic and enzyme effects.

V.B. Carcinogenic Studies - No carcinogenic studies, per se, were reported in the 1972 review of chlordane. However, chlordane was not reported at the time to be tumorigenic in long-term studies in rats or dogs.

In an 18-month feeding study, male and female Charles River CD-1 mice were fed chlordane in the diet at dosage levels of 5, 25, and 50 ppm. For those mice which were sacrificed after 18 months or which died during study, a large number of compound-related liver masses and nodules were observed in the 25 and 50 ppm chlordane feeding groups. Microscopically, hepatocytomegaly was observed in livers from mice of the three chlordane feeding groups, and a statistically significant increase in hepatic nodular hyperplasia occurred at the 25 and 50 ppm levels. Mice at the 25 ppm chlordane feeding level had a greater number of hepatomas than occurred in the untreated controls (Wazeter et al. (1973)

The National Cancer Institute has issued a preliminary report covering carcinogenicity testing of AG chlordane using both sexes of Osborne - Mendel rats and B6C3F1 mice. The AG chlordane was composed of approximately 65 percent alpha chlordane and 35 percent gamma chlordane. The AG chlordane was administered in the diets for a period of 80 weeks with sacrifice at approximately 90 weeks for the mouse and 110 weeks for the rat. The dose levels for AG chlordane in the diet were: 29.9 ppm (low), 30.1 ppm (low), 56.2 ppm (high), and 63.8 ppm (high) for the mice; and, 120.8 ppm (low), 203.5 ppm (low), 241.5 ppm (high), and 407.0 ppm (high) for the rats. The AG chlordane was found to be carcinogenic in the mouse with a high incidence of hepatocellular carcinomas. With the rats, the predominant lesions were hepatic nodules and hyperplasia of the liver. Also, an increase of thyroid/parathyroid tumors occurred in the male rats receiving AG chlordane. A complete histopathological report and final document is expected to follow this prelimary report. (National Cancer Institute, 1975).

V.C. Mutagenic and Teratogenic Studies - Brubaker et al. (1970) examined the effects of gamma chlordane on cell division and DNA synthesis utilizing synchronized mouse leukemia cells (L5178Y) grown in suspension culture. The cells were treated with 4 ug/ml gamma chlordane. Few treated cells reentered mitosis; instead they were arrested somewhere between the G-1 and G-2 phases of the cell cycle. The treated cells were as competent in DNA replication as control cells. However, 25-30% of the total DNA persisted as light density material. The authors concluded that the effect of gamma chlordane on cell division was not related directly to interference with DNA synthesis or the cleavage of mitotic cells, but may arrest the cells during the G-2 period.

V.D. Metabolic Studies - In the 1972 Review it was reported that a metabolite, oxychlordane, was recently found in mammalian fat, milk and cheese. It was reported to be an epoxide derivative of chlordane formed from both alpha and gamma chlordane.

Street and Blau (1972) reported oxychlordane storage in rat adipose tissue. Male and female rats were fed pure cis-and trans-chlordane or technical chlordane at levels from 50 to 200 ppm for 15 days. Trans-chlordane resulted in greater oxychlordane storage than cis-chlordane in both sexes with lower accompanying parent isomer storage. Males fed either isomer stored less oxychlordane than females. At 100 ppm in the diet, storage ratios of oxychlordane to chlordane for male and females respectively were: trans-chlordane, 4.3:1 and 20:1; cis-chlordane, 3.4:1 and 9.1:1. Oxychlordane storage during simultaneous administration of both chlordane isomers, or of technical chlordane itself, showed additivity of oxychlordane formation with no interaction apparent. The authors believe that results of incubating chlordane isomers with rat liver homogenate indicated that oxychlordane formation proceeds via a dehydrogenated intermediate, dichlorochlordene.

V.E. Effects of Chlordane on Enzymes - Ample evidence of enzyme induction by chlordane is presented in early papers reviewed. The following papers add to evidence for induction and suppression of enzyme systems.

Wiess et al. (1970) found that chlordane fed to rats at 10 or 50 ppm for varying times up to 12 months significantly decreased hexobarbital leeping time at one month. After 12 months, treated rats showed a trend toward decreased pentylenetitrazal and hexaflourodiethyl ether convulsive thresholds. Hepatic enzyme induction was postulated as the result of chlordane administration.

Kinoshita and Kempf (1970) fed various levels of chlordane, gamma chlordane, heptachlor and heptachlor epoxide to male and female rats for 13 weeks. Three hepatic microsomal enzymes, phosphorothioate detoxification, O-demethylase, and N-demethylase, were induced in a dose-related manner. Elevated enzyme

activity was maintained throughout the feeding period. The more persistent induction occurred with heptachlor and heptachlor epoxide. The "no effect" dietary levels for enzyme induction by the administered pesticides were approximately 1 ppm. The reported descending order of potency for the chlordane and heptachlor materials as hepatic microsomal enzyme inducers were: heptachlor epoxide, heptachlor, chlordane and gamma chlordane.

Rats treated with a single dose (100 mg/kg) of chlordane (Lechner and Pousada, 1971) showed significantly increased capacities of oxidative drug metabolism 24 hr after administration, and even more strongly at 48 hr, while RNase activity was reduced to less than 50% of normal at 10 hr.

Pardini et al. (1971) reported that heptachlor and chlordane depressed the mitochondrial succinoxidase system to 5.8 and 21.5% of the uninhibited controls. Both compounds also depressed mitochondiral NADH-oxidase activity to 8.6 and 10.1%, respectively, of the controls. The authors speculate that since heptachlor and chlordane did not interact after cytochrome C, the site of inhibition interaction may be either at complex III or at complexes I and II.

Kacew and Singhal (1973) reported that daily intramuscular injections of alpha chlordane (5 mg/kg) for 45 days significantly stimulated the activities of pyruvate carboxylase, phos-phoenolpyruvate carboxykinase, fructose-1, 6-diphosphatase and glucose-6-phosphatase in liver and kidney cortex of male rats. Exposure for 45 days at 25 mg/kg also elevated the concentration of serum urea.

V.E.1. Miscellaneous Effects - Santolucito and Whitcomb (1971) studies the mechanical response characteristic of the soleus muscle, in situ, in rats orally dosed with 260 mg/kg chlordane. Characteristics of performance measured were the stimulation frequency required and tension developed for complete tetanus; frequency of stimulation required and tension developed for maximum tension; time constants for tetanic contraction and relaxation; and, single contraction tension and duration. Chlordane did not alter any of the responses characteristic of the soleus muscle at the dose studies.

CHAPTER V

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CHAPTER VI

Toxicology and Epidemiology of Heptachlor

VI.A. Introduction - A review of literature available on heptachlor since 1972 has revealed new information on subacute oral toxicity, effects on reproduction, carcinogenicity, metabolism, enzyme induction, and human epidemiology.

VI.B. Subacute Oral Toxicity - The toxicity of heptachlor was studied by Webb and Miranda (1973) in male weanling rats fed different types (gluten or casein) protein for 10 days at two levels of protein intake. With a dietary protein level of 10%, heptachlor was less acutely toxic in rats fed an unsupplemented gluten diet than in animals pair-fed diets containing gluten plus amino acids or casein plus 0.2% DL-methionine. When the level of dietary protein was raised to 18%, heptachlor was twice as toxic to rats pair-fed casein diets as the rats fed unsupplemented gluten. The clinical syndrome of intoxication was not affected by the quality of dietary protein fed. Animals fed casein diets ad libitum were less susceptible to heptachlor intoxication than were rats fed the same diets at a restricted level of intake. The authors speculated that the differences in heptachlor toxicity with variations in the quality of the dietary protein may be due to differences in rate of activation of heptachlor in vivo and that impairment of the conversion of heptachlor to its epoxide probably occurs in rats fed poor quality protein.

VI.C. Effects on Reproduction - The results of reproductive effects of heptachlor epoxide on the hatchability of white leghorn eggs in the 1972 review of heptachlor is supported by one additional study. Smith et al. (1970) studied several chlorinated pesticides, including heptachlor, by injecting them via a corn oil carrier into fertile hen eggs. A 1.5 mg injection of heptachlor resulted in a 12% reduction in hatchability. All test chicks appeared normal. The authors concluded that quite substantial amounts of chlorinated hydrocarbon pesticides must be injected to observe a sharp decline in hatchability.

VI.D. Carcinogenicity - Since 1972, additional studies have been completed. Cabral et al. (1972) administered 10 mg/kg heptachlor, in grain oil, to rats from birth to 10 days of age. Twenty-nine rats were killed at 60 weeks to detect early changes. Changes in histopathology were absent. Growth and survival rates were similar in the experimental and control groups. No liver tumors were observed in either sex. Incidence of tumors among males was substantially the same in the treated and control groups. Among females surviving 80 weeks, 9 of 28 heptachlor treated animals developed a total of 12 tumors (5 of them mammary), while in the controls, 4 out of 27 developed a total of 4 tumors (2 of them mammary). Tumor incidence associated with the thyroid, the adrenals, and pituitary in the treated and control groups was comparable. The authors concluded that the administration of heptachlor to rats, in oral doses of 50 mg/kg during the suckling period, showed no carcinogenic effect.

In an 18-month feeding study, male and female Charles River CD-1 mice were fed a mixture of 75 percent heptachlor epoxide - 25 percent heptachlor in the diet at dosage levels of 1, 5 and 10 ppm. For those mice which were sacrificed after 18 months or which died during the study, a large number of compound-related liver masses were observed in the groups which received 5 or 10 ppm of heptachlor epoxide/heptachlor. Microscopically, the livers of male mice from the 1, 5 and 10 ppm levels of heptachlor epoxide/heptachlor feeding and the livers of females from the 5 and 10 ppm levels of heptachlor epoxide/heptachlor had compound-related hepatocytomegaly. Liver weights of female mice on 1, 5 and 10 ppm of heptachlor epoxide/heptachlor were significantly increased. Mice from the 5 and 10 ppm feeding levels of heptachlor epoxide/heptachlor had nodular hyperplasia of the liver. These lesions, which occurred with a dosage-related incidence and severity, were considered compound-related (Wazeter et al. 1973)

The National Cancer Institute has issued a preliminary report covering carcinogenicity testing of technical grade heptachlor using both sexes of Osborne-Mendel rats and B6C3F1 mice. The technical grade heptachlor was composed of 74 percent heptachlor with the remainder being essentially alpha chlordane. The technical grade heptachlor was administered in the diets for a period of 80 weeks with sacrifice at approximately 90 weeks for the mouse and 110 weeks for the rat. The dose levels for technical grade heptachlor in the diet were: 6.1 ppm (low), 9.0 ppm (low), 13.8 ppm (high), and 18.0 ppm (high) for the mice; and, 18.9 ppm (low), 18.9 ppm (low), 37.8 ppm (high), and 77.9 ppm (high) for the rats. The technical grade heptachlor was found to be carcinogenic in the mouse with a high incidence of hepatocellular carcinomas. With the rats, the predominant lesions were hepatic nodules and hyperplasia of the liver. A complete histopathological report and final document will follow this preliminary report. (National Cancer Institute, 1975).

VI.E. Metabolism - Mizyukova and Kurchatov (1970) gave female rats a single dose (120 mg/kg) of heptachlor and found that the compound reaches all organs and tissues within the first hour after dosing. It is rapidly metabolized to form the epoxide which accumulates in the fatty tissue. The concentration of heptachlor in all organs and tissue falls at the same time as its concentration in the fatty tissue falls, and the epoxide reaches its maximum accumulation in fatty tissue with scarcely any of it excreted.

Matsumura and Nelson (1971) fed heptachlor epoxide (99%) to 4 male rats at 10 ppm for 30 days. The rats excreted 950 µg of a fecal metabolite and 66 µg of heptachlor epoxide in the feces. The evidence indicated that the structure of the metabolite is as follows:

De Vos et al. (1972) fed several pesticides, including heptachlor, to day-old broiler chicks at levels of 0.05, 0.14 and 0.40 ppm for a period of 7 weeks. Heptachlor epoxide residue levels in fat were 11 times the level in feed.

Dobson et al. (1972) reported that hogs pasturing on corn stover accumulated measurable residues of heptachlor epoxide in fat, 0.032 to 0.071 ppm. Removal of the animals to concrete slabs for further fattening and varying periods of time reduced but did not eliminate these residues.

VI.F. Enzyme Induction - Kinoshita and Kempf (1970) fed various levels of chlordane, gamma chlordane, heptachlor and heptachlor epoxide to male and female rats for 31 weeks. Three hepatic microsomal enzymes, phosphorothioate detoxification, O-demethylase, and N-demethylase, were induced in a dose related manner. Elevated enzyme activity was maintained throughout the feeding period. The more persistent induction occurred with heptachlor and heptachlor epoxide. The "no effect" dietary level for enzyme induction was approximately 1 ppm. The reported descending order of potency for hepatic microsomal enzyme induction was: heptachlor epoxide, heptachlor, chlordane and gamma chlordane.

Pardini et al. (1971) reported that heptachlor and chlordane depressed the mitochondrial succinoxidase system to 5.8% and 21% of the uninhibited controls. Both compounds also depressed mitochondrial NADA-oxidase activity to 8.6 and 10% respectively of the controls at 1 μ mole/flask. The authors speculate that since heptachlor and chlordane did not interact after cytochrome C, the site of inhibition interaction may be either at complex I-II or at complex I and III.

Krampl (1971) intubated female Wistar rats with 60 mg/kg of heptachlor (single dose), and other groups received 7 or 12 mg/kg daily for 28 days. At 2 hr after a single dose, activity of glutamic pyruvic transaminase in liver significantly increased, but at 72 hr it decreased below normal. The decreases were significant on the 7th day for the 7 mg/kg dosage and on the 7th and 14th day for the 12 mg/kg dosage. The terminal values were approximately at base value for both groups by the 28th day. Changes in aldolase activity in liver and serum for both groups (single and multiple dose) showed similar effects over time.

VI.G. Epidemiological Studies - Hunter (1968) tabulated data for four pesticides in adipose tissue from Australia, India, Israel, Italy, the U.K. and the U.S.A. He related the data to maximum human tissue concentrations found with and without intoxication (male adults). From this information, the respective adipose tissue and whole blood values of 0.5 mg/g and 1.5 mg/l for heptachlor epoxide were proposed as allowable.

Casarett and Fryer (1968) analyzed as many as 12 tissues from 44 autopsies in Hawaii for some common organochlorine pesticides. Subjects ranged from 28 weeks gestation to 88 yr old. The levels of heptachlor epoxide in the 12 types of tissue ranged from 0.01 ppm in brain to 0.09 ppm in liver. In general, the organochlorine pesticide levels corresponded with the extractible lipid content of the tissue, except in the brain.

Zavon et al. (1969) collected and analyzed skin, fat and attached subcutaneous tissue of 68 neonates from 13 U.S. cities. Fifty-six of the specimens were from stillborn infants who died within one week of birth. The average of results based on total weight of samples was 0.060 ppm heptachlor epoxide. Differences in levels by sex were considered inconsequential.

Data for heptachlor epoxide in maternal blood and placental tissues from 53 women spontaneously delivered in a Louisiana parish in 1966-67 were reported by Selby et al. (1969). Heptachlor was detected in the blood of 15 individuals (mean 0.13 ppb, range 0.1-0.2 ppb). Heptachlor epoxide was detected in the blood of 42 individuals (mean 0.21 ppb, range 0.1-0.6 ppb). The mean for heptachlor in the placental tissue of 3 individuals was 6.23 ppb, and the range was 2.0-52.0 ppb. The mean placental tissue value for heptachlor epoxide in 11 individuals was 1.21 ppb, and the range was 0.1-6.5 ppb.

Heydrickx and Maes (1969) investigated several chlorinated hydrocarbon insecticides in the lipid fraction of human milk. Four samples out of 20 contained heptachlor epoxide, ranging from 0.001 to 0.003 ppm. The authors also reported that heptachlor transferred from pregnant guinea pigs to the fetus via the placenta.

Curley et al. (1969) reported the following ppm levels of heptachlor epoxide in tissue from 10 autopsies of stillborns.

Tissue	Mean	SE*	Range
Adipose	0.32	0.10	0.07-0.51
Spinal Cord	-	-	-
Brain	0.13	-	-
Adrenals	0.73	0.27	0.46-1.00
Lungs	0.17	0.07	0.08-0.31
Heart	0.80	0.30	0.30-1.56
Liver	0.68	0.50	0.03-1.67
Kidney	0.70	0.28	0.19-1.14
Spleen	0.35	0.08	0.10-0.52
Pancreas	-	-	-

In a study of 1000 serum samples from people in southern Idaho, Watson et al. (1970) found heptachlor epoxide in 2.2% of the samples. Levels ranged from 0-5 ppb.

Nishimoto et al. (1970) analyzed 74 human adipose tissue samples for heptachlor epoxide. The subjects were over 24 years of age. The compound was found at an arithmetic mean of 0.01 ppm and a range of 0 to 0.09 ppm.

In thirty-one samples of omentum fat (biopsy) from the Province of Trento, Italy, Prati and Del Dot (1971) did not find heptachlor. Heptachlor epoxide was found in 19.4% of the samples with a geometric mean of 0.010 ppm.

Doguchi et al. (1971) analyzed 21 samples of human abdominal fat tissues from females residing in metropolitan Tokyo. Gas chromatography detected heptachlor epoxide levels ranging from 0 to 0.14 ppm with a mean of 0.04 ppm.

Paired samples of serum and adipose tissue from patients undergoing abdominal surgery were analyzed to determine residue levels of several chlorinated hydrocarbon pesticides by Wyllie et al. (1972). Blood and adipose tissue were obtained from 141 female and 61 male Caucasians. Heptachlor epoxide was found in 18% of the serum samples (0-2 ppb range, mean 0.1 ppb) and 97% of the adipose samples (0-1.3 ppm, range, mean 0.1 ppm).

Wassermann et al. (1972) used gas chromatographic methods to analyze 268 adipose tissues collected during the autopsy of Nigerians who had no occupational exposure to organochlorine insecticides. Heptachlor epoxide was found in all tissues examined. In stillborn, heptachlor epoxide was present at 0.006 ppm. Heptachlor epoxide was found as follows: 0-11 months children, 0.012 ppm; 1-4 years old, 0.006 ppm; 5-24 years old, 0.004 ppm; and, 45+ years of age, 0.02 ppm.

Similar analyses were performed by Wassermann et al. (1974) on adipose tissues from 307 autopsies of Israelis. Concentrations of heptachlor epoxide in adipose tissues of stillborns averaged below 0.01 ppm, indicating, according to the authors, accumulation during fetal life and the ability of the compound to cross the placental barrier. The mean concentrations in the tissues of various age groups were:

Age Groups	ppm
Stillborn	0.0030 ± 0.0028
0-11 months	0.0007 ± 0.0025
5-24 yr.	0.0211 ± 0.0412
25-44 yr.	0.0205 ± 0.0316
45-63 yr.	0.0251 ± 0.0192
70+ yr.	0.0102 ± 0.0027

In the United Kingdom during the period 1969-71, samples of human fat were taken during routine necropsies of 201 subjects over 5 years of age and of 20 stillborn by Abbott et al. (1972). In subjects under 5 yr old, heptachlor

epoxide levels were reported as: arithmetic mean, 0.03 mg/kg; range, 0-0.14 mg/kg. The number of positive samples was not given nor were values for stillborn separated from the values of those under 5 yr.

Prati et al. (1972) analyzed tissue of autopsy and biopsy subjects from Ferrara Province, Italy for heptachlor epoxide and found the following percent-positive samples: 52 autopsy fat, 69.2%; 33 biopsy fat, 54.5%; 23 liver, 34.8%; 15 kidney, 0%; 15 brain, 0%; and 13 spleen, 7.7%. The mean levels and ranges were: autopsy fat, 0.51 ppm, 0-1.58 ppm; biopsy fat, 0.24 ppm, 0-1.02 ppm; liver, 0.07 ppm, 0-0.34 ppm; and spleen, only one positive sample, 0.19 ppm.

Burns (1974) reported on residues in adipose tissue from elective surgery subjects in the Rio Grande Valley, Texas. Heptachlor epoxide levels ranged from 0.08 ± 0.07 to 0.14 ± 0.13 ppm for the years 1969-72.

Kutz et al. (1974) reported a survey of human adipose tissue residues for several pesticides. The survey for 1970 covered 32 cities in four census regions of the contiguous 48 states. Heptachlor epoxide was detected in 76% of 1,412 samples. The levels ranged from 0 to 10.62 ppm on a percent lipid basis. The median, geometric and arithmetic means were: 0.08; 0.09; and, 0.17 ppm, respectively.

Heptachlor epoxide has been detected in human milk. Larsen et al. (1971) found two positive samples in 31 analyses in British Columbia. The levels were 0.052 and 0.013 ppm. Fifty samples of human milk from mothers (18-32 years) living in Leiden, Netherlands were analyzed by Tuinstra (1971) during the last three months of 1969. Heptachlor epoxide was detected in all samples, median 0.06 - 0.028 ppm, range - 0.13-0.15 ppm. The author states that the WHO/FAO average daily intake for heptachlor epoxide is 0.5 g/kg/day, and that babies would consume 0.19 g/kg/day. From November 1971 to March 1972, Hayashi (1972) analyzed 398 samples of milk from mothers in all 336 Japanese prefectures. Heptachlor epoxide was present at 0.0011 ppm (arithmetic mean) or 0.007 ppm (geometric mean). Savage et al. (1973) reported on 40 human milk samples from rural Colorado. Twenty-five percent of the samples contained heptachlor epoxide at levels ranging from a trace to 5 ppb.

CHAPTER VI

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